Product Engineering

THE McGRAW-HILL MAGAZINE OF DESIGN ENGINEERING

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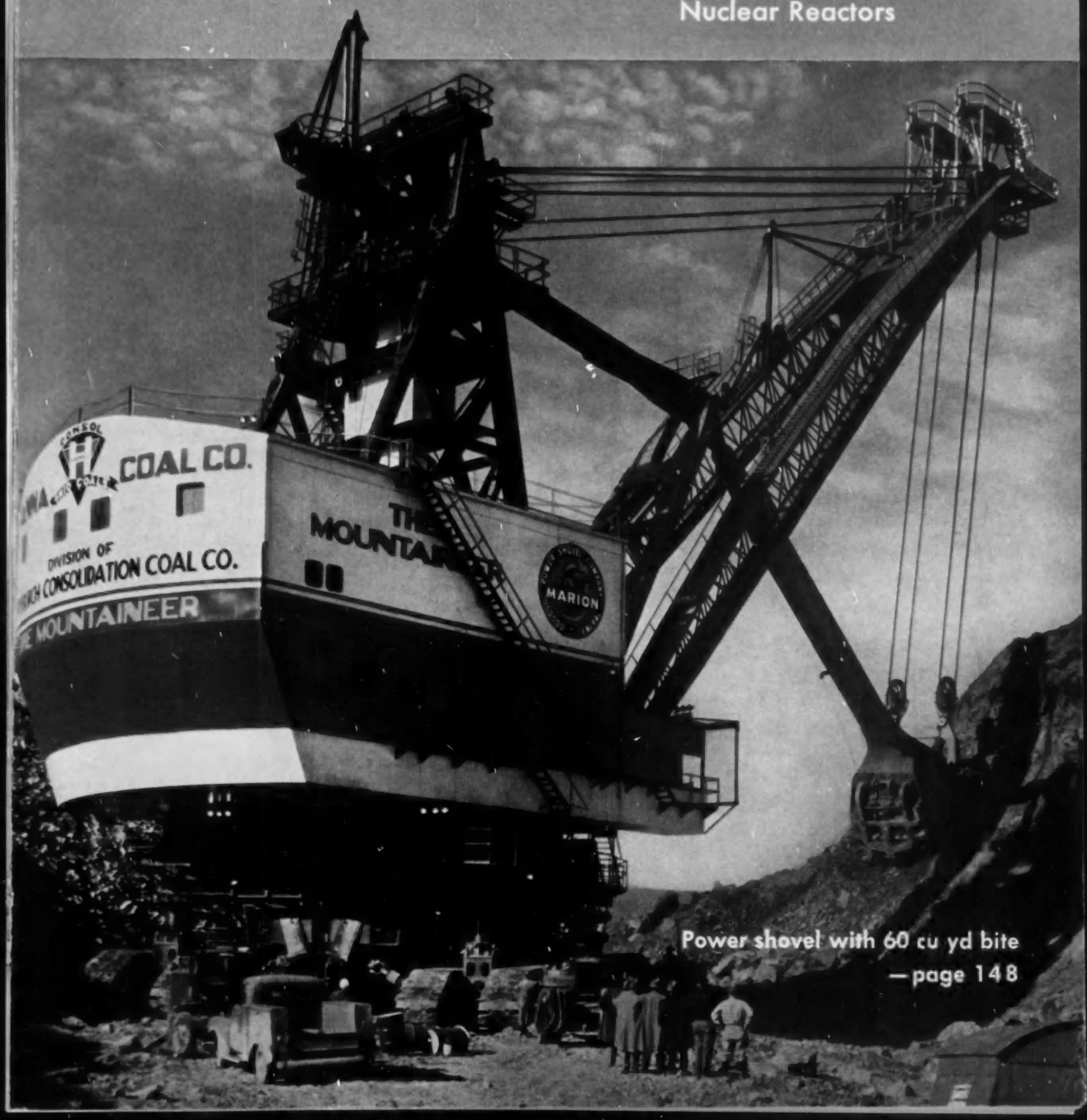
MAY 1956

Lubrication
of gear drives

Plastic Resins

Capacitor Motors

Nuclear Reactors



Power shovel with 60 cu yd bite
—page 148

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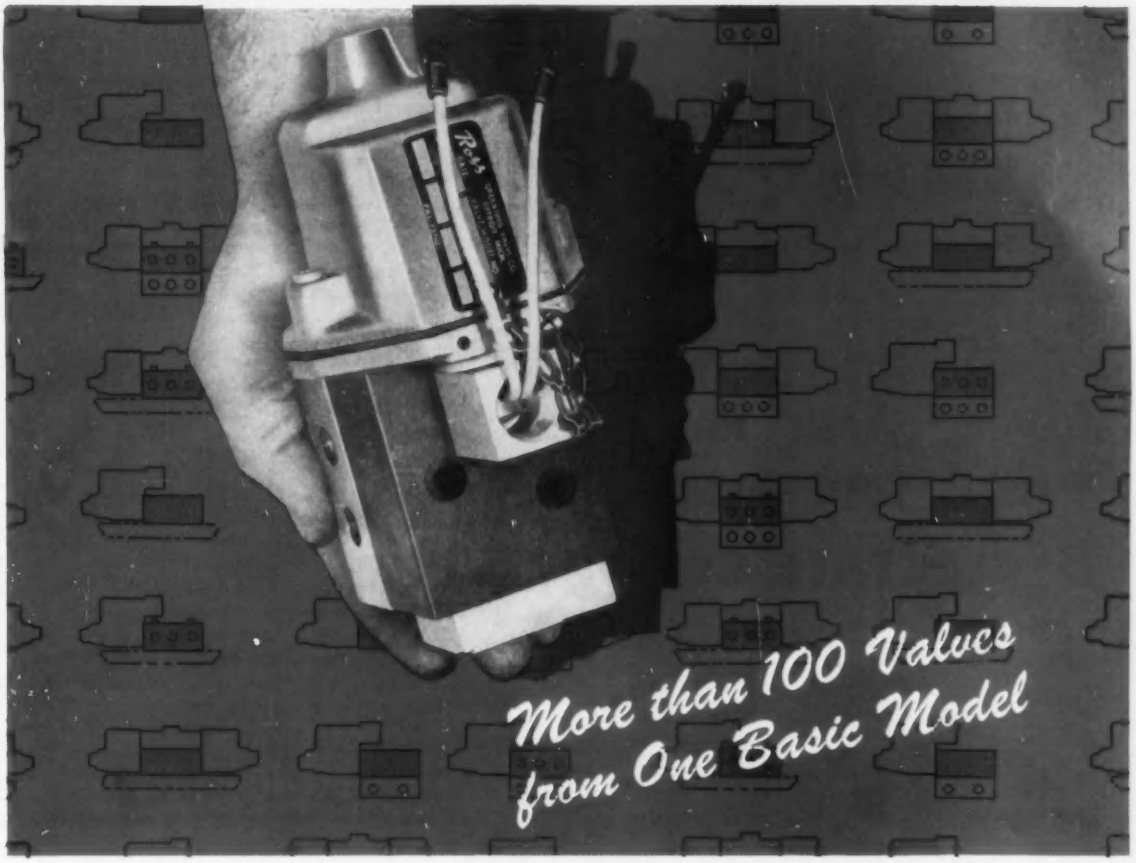

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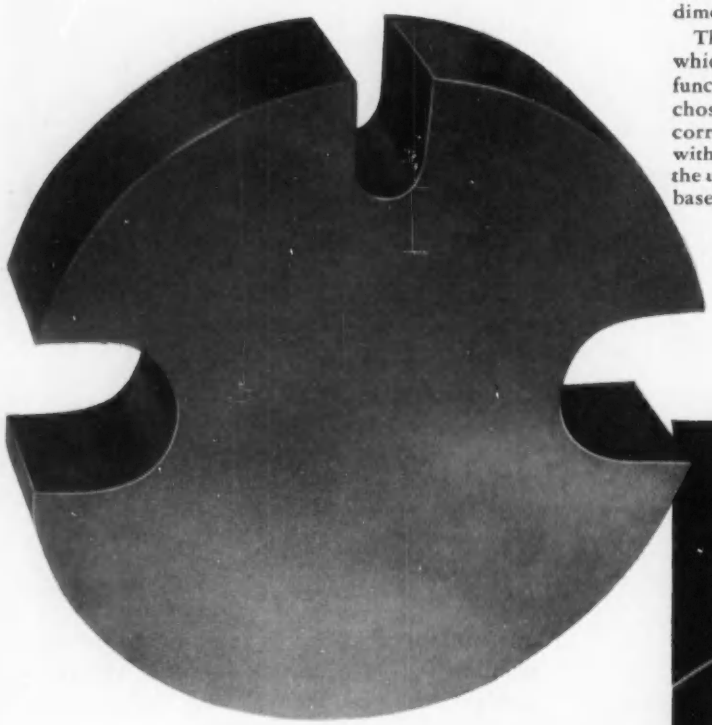
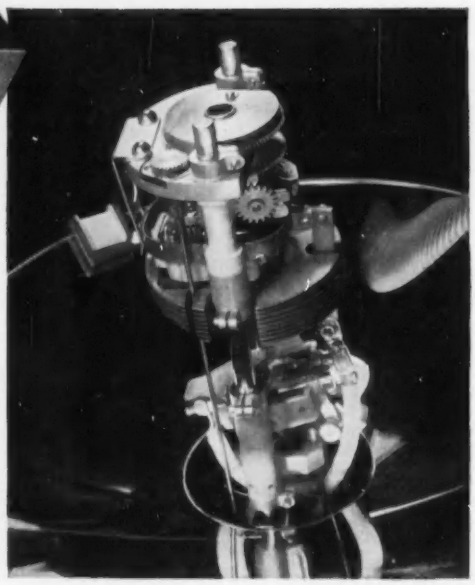
The customer is The Strong Electric Corp., Toledo 2, Ohio, which originally tried plate and bar, but found costs were too high. Revere Product Engineers, Methods and Production Departments collaborated with the company on the problem, and were able to develop the unusually heavy and economical shape. Strong reports a number of savings. One is that the shape is machined quickly and perfectly, with almost no rejects. This is due to the denseness and uniformity of the metal, a result of the high pressures exerted during extrusion. (Finishing operations include drilling bolt holes and cutting cooling fins.) As a secondary result of improved machining, the customer does not have to keep large inventories of metal to take care of spoilage, nor handle large quantities of scrap. Further, Revere supplies the discs in the correct thickness, eliminating a cutting-off operation for Strong. Incidentally, we are glad to supply shapes cut to dimensions, or in long lengths, as desired.

The completed part is an obturator-probe, which fulfills a control and heat dissipation function in a powerful searchlight. Copper was chosen for its ability to conduct heat and resist corrosion. Revere will be glad to collaborate with you in your search for economies through the use of extruded shapes in copper and copper-base alloys, and aluminum alloys.



Copper Extruded Shape, 1 3/16" x 5", as furnished.



Shape in place in a carbon arc searchlight mechanism.

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Product Engineering

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The McGraw-Hill Magazine of Design Engineering

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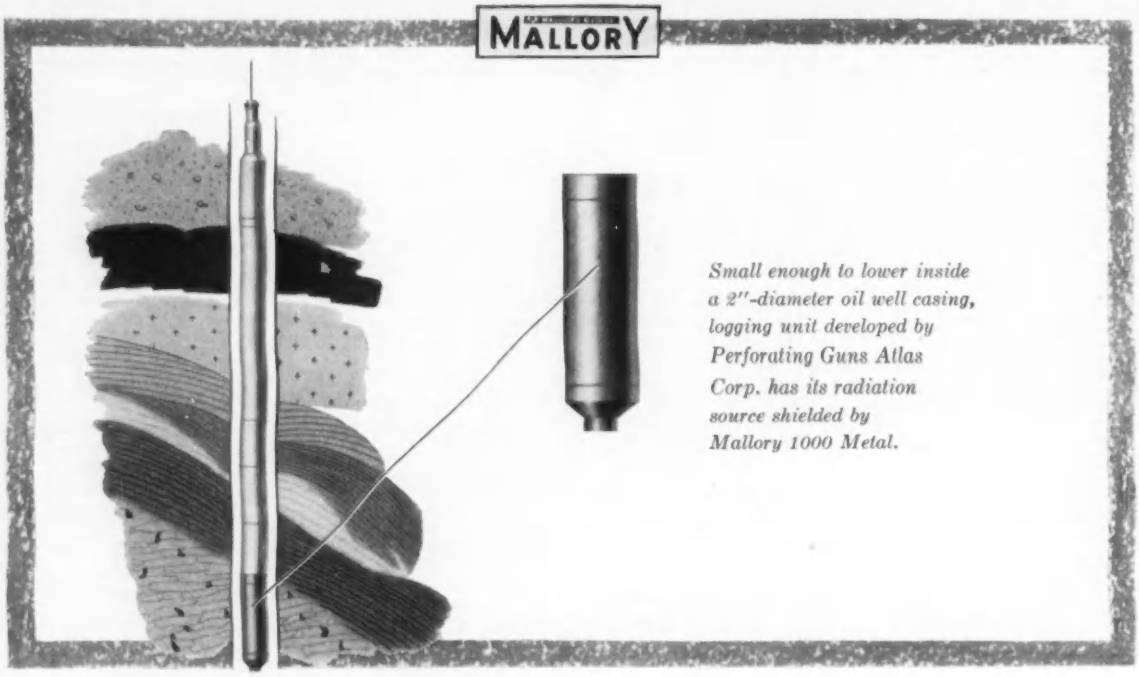
MALLORY



Small enough to lower inside a 2"-diameter oil well casing, logging unit developed by Perforating Guns Atlas Corp. has its radiation source shielded by Mallory 1000 Metal.

New oil well logging technique uses Mallory 1000 for radiation shielding

AN EXCEPTIONALLY ACCURATE method for examining oil wells for possible oil-rich strata has been developed recently by Perforating Guns Atlas Corporation. Based on simultaneous logging of gamma and neutron radiation, this equipment eliminates major sources of error in radiation logging. It is applied not only to new wells, but also to location of new producing levels in old wells.

To permit servicing of wells that already have small diameter casing or tubing installed, the logging unit is designed with an outside diameter of only 1¾". At its lower tip, a precisely machined cylinder of Mallory 1000 metal holds the radioactive source.

Use of this highly efficient shielding material provides, in the limited space available, effective suppression of undesirable radiation in unwanted directions. Exceptionally uniform in density, and free from internal voids that would detract from absorptive qualities, Mallory 1000 assures predictable performance essential to overall precision of measurement. It is readily machined to the close tolerances required. And its mechanical strength and weathering properties meet every requirement of this work.

Mallory 1000, a unique product of Mallory powder metallurgy, is proved by test and extensive use to be up to 30% more effective than lead in shielding radiation up to MEV levels. Its extreme density and high mechanical strength also make it valuable for counterweights, gyroscope rotors and similar mass components. Write to Mallory today for complete technical data and absorption characteristics.

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THIS MONTH'S COVER

The world's largest shovel, 160 ft to top of boom and a 60 cu yd dipper, (built by Marion for Hanna Coal) can dig and stack 7000 tons of strip mine overburden in an hour. For some of the mechanical design problems faced, particularly the part played by high-strength heat treated alloy steel, see the story starting on page 148. Some of the drive and control accomplishments will be the subject of a later article.

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Developments

To Watch

CASTING CRANKSHAFTS . . . .

. . . . by a method developed at the Central Foundry Division of General Motors, means a shift to the mass production of cast crankshafts for automobile engines. This division of GM at Danville, Ill., is now mass producing all of Pontiac's requirements by this method. Formerly, crankshafts have been drop forged from steel; now, GM is casting crankshafts from ArmaSteel, a new type of pearlitic malleable iron cast from their regular base metal, but modified by alloys based on a composition developed at GM's Technical Center in Detroit. Minute alloy additions are on the order of two parts in 10,000 of bismuth, and four parts in 100,000 of boron. Manufacturing economies made possible by the new casting method are in the form of reduced machining time. The rough weight of a forged V-8 crankshaft was 76 lb, which was machined to 58 lb, a difference of 18 pounds. With the new casting, the rough weight is 64 lb, and is machined to 54 lb, a difference of 10 lb, or a savings of 8 lb of machining per crankshaft. Other advantages are: wider latitude of design; good dimensional control, unlimited supply of non-critical material, and better machine ability.

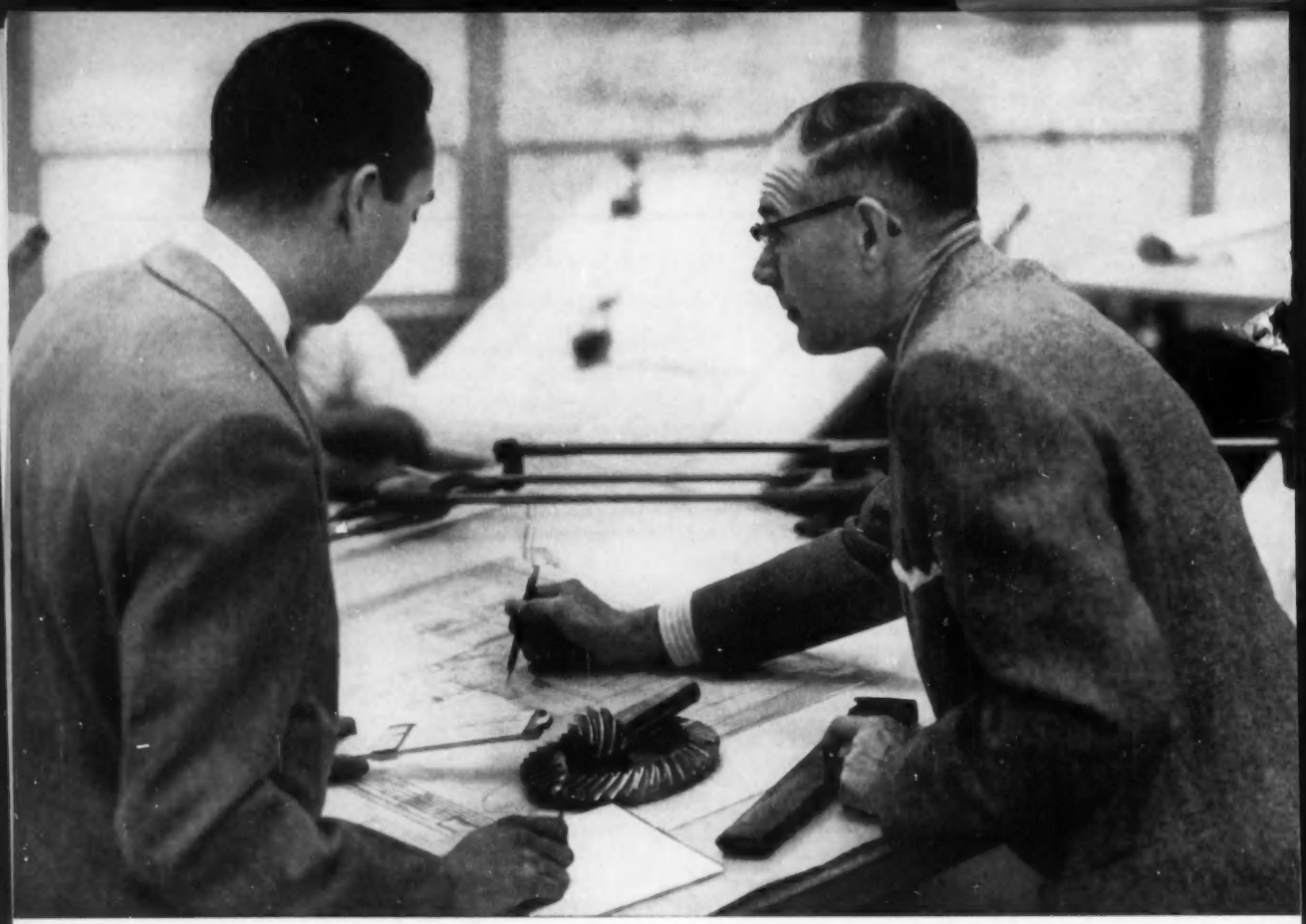
A PORTABLE METAL HARDNESS TESTER . . . .

. . . . gives direct readings corresponding to Rockwell, A, B or C scales, or Brinell Medium or Low scales. The tester, sold by Newage International, Inc., 222 York Rd., Jenkintown, Pa., can get accurate readings on any size, shape, or type of material, without cutting a sample from the work. The tester is placed on the metal, the handgrips are pressed down, and the dial is read. The new unit eliminates the base-plate or pressure screw clamp attachment, and the need for conversion charts. Each instrument is individually calibrated to a tolerance of from zero to plus 1.5 pts Rockwell, and 5 pts Brinell. There is no limitation as to thick or thin sections. For continuous-run testing, a special bench adapter is available.

ALUMINUM JOINT CORROSION IS AVOIDED . . . .

. . . . when welding is done without the use of flux, according to a report from Chemalloy Electronics Corp., Santee, Calif. This is true of castings, sheet, and foil, and no special cleaning or removal of the oxide surface film is required. A soldering alloy composed of lead and zinc is used at temperatures of 800 F or lower. A joining material of 85 per cent zinc, 1.4 per cent lead, 0.6 per cent tin, 8.0 per cent aluminum, and 5.0 per cent copper will develop 50,000 psi tensile strength in the joint. Silver added to the solder is said to improve the quality. All of these solder blends can be polished, plated and machined.

(Continued on page 7)



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Now you can produce small quantities of spiral bevel, Zerol® bevel and hypoid gears with a comparatively small capital outlay and without specially trained personnel.

You can reduce the time and expense it takes to change your angular drive from a drawing board idea to a working model, too, because the Unitool Method produces good quality gears directly from the initial calculations.

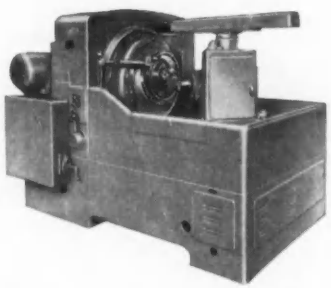
The Unitool Method is based on a fundamentally different theoretical approach to bevel gear generation. Only six different cutters are required to cut gears up to 14" pitch diameter—spiral bevel and Zerol bevel pairs of any ratio; hypoid pairs 3:1 ratio and higher. Because these cutters have a wide overlap in range, cutter diameter is not critical.

Calculations are short enough and easy enough for you to do in your own plant. Correct tooth thickness and position of contact are easily determined without requiring special operator training.

The Unitool Method is designed especially for the Gleason No. 106 and No. 116 Hypoid Generators which feature increased universal cutter tilt.

*Trademark

We will be glad to send further information on the Unitool Method and the two Gleason Generators best suited for it at your request.



The Gleason No. 106 Hypoid Generator is a high-speed machine for spiral bevel, Zerol bevel and hypoid gears up to 8½" pitch diameter. Its larger counterpart, the No. 116 Hypoid Generator, handles the same type gears up to 18" pitch diameter.

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Developments to Watch

INSPECTING GLASS-REINFORCED PLASTIC LAMINATES . . . .

. . . . by nondestructive techniques is being investigated at Battelle Memorial Institute, Columbus 1, Ohio. To date the most promising techniques appear to be ultrasonic inspection by through-transmissions and resonant-frequency methods, and dielectric testing with a capacitance type probe. In the ultrasonic through-transmission test, the specimen is passed between a crystal generating ultrasound, and another crystal receiving ultrasound. The receiving crystal produces an electrical signal proportional to the ultrasound impinging on it. Any defects or discontinuities are revealed by the decreased magnitude of the received signal. Panels up to $\frac{1}{2}$ in. thick can be tested, but the method is limited to small parts inspection. In another method, an instrument transmits ultrasound of varying frequency to the specimen. When the specimen receives that frequency which is characteristic of its thickness, it will resonate, producing changes that may be measured in the electrical circuit. The dielectric test uses a capacitance type probe which is a modification of a patented thickness gage.

ELECTRICALLY INSULATED METAL FOIL . . . .

. . . . with a continuous coating of Teflon on one or both sides has been announced by the American Machine & Foundry Co., 261 Madison Ave., New York 16, N. Y. Tradenamed Amfoil, it consists of many metals coated with Teflon, but major developmental work to date has been with aluminum in thicknesses from 0.2 to 2.0 mils. Coating thickness can be varied from 0.03 to 0.5 mil per side, and held to ± 10 per cent of any desired film thickness. Principal use appears to be in sub-miniature capacitors, coil forms, transformers, shielding, and flexible packaging. The combination of aluminum and Teflon produces a high temperature (400 F) dielectric material that is chemically inert and non-adhesive.

ELIMINATING SPRING-BACK IN FORMING TITANIUM SHEET . . . .

. . . . and strip is possible by getting the sheet and strip to closer specifications, by special handling of the sheet, and by hot forming under controlled temperature conditions. A temperature of 450 to 600 F, using cartridge heated dies has been found to work well according to work done at the Bell Aircraft Co., Buffalo, N. Y. Controlling the yield point within ± 5000 of the specified limit is beneficial, but a knowledge of the exact value is more helpful.

PRINTED ELECTRICAL CIRCUITS BY XEROGRAPHY . . . .

. . . . formerly a process used only in office and graphic arts reproduction, is said to offer savings in time and money for model shop work, prototype circuit studies, and short production runs. In the new application, the powder image used in xerography is transferred from a selenium plate to a sheet of transfer paper, then to the face of a copper-clad laminate. Here the powder forms a photo-exact resist pattern impervious to chemical attack. In the following etching step, acid eats away the copper unprotected by the resist pattern, or circuit diagram. The xerographic powder or resist, is then removed by a solvent. From an original opaque drawing, a copper-clad laminate serving as a printed circuit or wiring board can be prepared for etching in 10 min. Except for the etching, the xerographic method is dry, and does not require photographic materials or darkroom. The Haloid Co., Rochester 3, N. Y. developed the new process. (*Continued on page 9*)

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Developments to Watch

ARC WELDING UNALLOYED TITANIUM . . . .

. . . . can be accomplished successfully if adequate protection is given. This consists of performing the work in a chamber filled with argon or helium gas, and protecting the weld by a stream of the same inert gas issuing from the torch. According to work done by the U.S. Bureau of Mines at College Park, Md., better results are obtained with a trailing shield, and a consumable electrode is advised for the heavy gage metal. The arc must be held longer because of the higher melting point of titanium. Due to the chemical activity of titanium at high temperature, particularly above 1450 F, this technique is essential to obtain good welds.

SMALLEST HERMETICALLY SEALED CAPACITOR . . . .

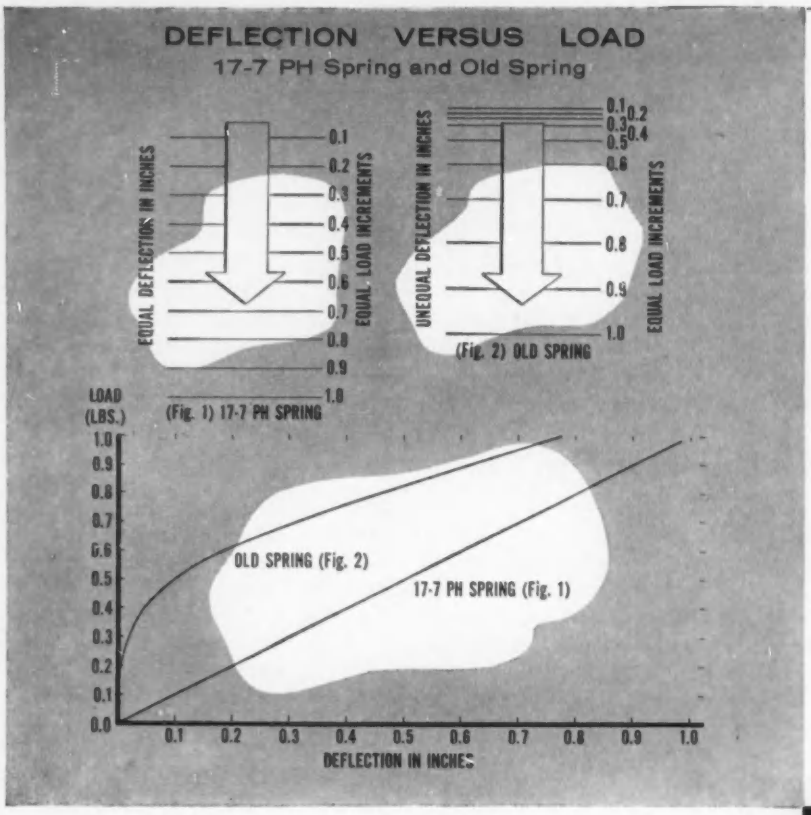
. . . . measures only $\frac{1}{8}$ in. in dia, and is $\frac{1}{4}$ in. long. Made by Sprague Electric Co., North Adams, Mass., it uses a new "solid electrolyte" tantalum anode construction, and has an electrical storage capacity of 12 microfarads. It occupies $\frac{1}{10}$ the space of an aluminum electrolytic capacitor of the same electrical capacity now used in transistorized hearing aids and pocket radios. The new capacitor uses a spongy positive plate made of powdered tantalum metal by pressing it in a die and then heating it. It differs from previous tantalum capacitors in that the electrolyte with which it is impregnated is a solid semi-conducting material instead of a liquid acid or paste of strong salts. Capacitance value changes only 5 per cent from room temperature to —132 F and up to 185 F. With other electrical properties unaffected in this temperature range, the capacitor has potential application in computers, radar equipment, navigation and guided missiles.

CALLED A NEW SUPER ALLOY . . . .

. . . . Udimet 500 is now being produced in production quantities at the Metals Div. of Utica Drop Forge & Tool Corp., Utica, N. Y. Now being vacuum melted in 1000 lb furnaces, Udimet 500 is reported to have an ultimate tensile strength of 100,000 psi at 1600 F, and will withstand a constant stress of 28,000 psi for over 100 hr. Basically, the new metal is a nickel-chromium-cobalt alloy with 3 per cent each of aluminum and titanium. About 60,000 lb of this material is produced a month, and is rolled into bar-stock or strip. Applications are turbine buckets, bolts and fasteners, and sheet material for high temperature applications.

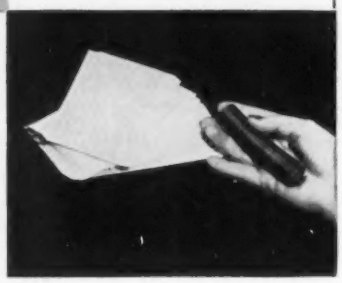
AND IN ADDITION . . . .

. . . . the car radio business grossed $364,-million in 1955; 5,600,000 car radios were factory installed in 1955 as opposed to 3,850,000 in 1954. . . . Tax relief for small firms will be proposed by the senate; two amendments will be offered to a bill continuing present corporation taxes for another year; both amendments would cut to 22 per cent from 30 per cent the tax rate on net profits up to $25,000 a year. . . . The effects of nuclear irradiation, high intensity noise, high rates of heating, and non-sinusoidal and non-periodic vibration on aircraft electrical equipment are now being investigated by Convair. . . . Fast escort vessels in the British Navy are to get new high pressure, high temperature steam turbines for cruising, with booster gas turbines, for sustained high speed bursts; both turbines will be geared to the same shaft. . . . A growth of at least 10 per cent in 1956 is estimated for the automation equipment industry, with the big move towards automation for assembly operations. . . . Research Labs of Fansteel Metallurgical Corps., N. Chicago, Ill., announce a new rectifier made from titanium oxide; soon to be available in a variety of sizes and ratings, its high point is simplicity of design. . . .



(Fig. 1). The 17-7 PH spring deflects equal increments with each additional 0.1 pound load. The first 0.1 pound deflects the spring almost exactly the same amount as the last 0.1 pound.

(Fig. 2). The old spring deflects unequal increments. Deflection at the first 0.1 pound load is entirely different from the last.



Armco 17-7 PH Wire Solves Stacker-Spring Problem at Lowest Cost

Ideal physical properties and relatively low cost made Armco 17-7 PH Stainless Steel wire top choice for stacker-springs in a new 1000-card-a-minute sorter.

Stacker-springs on this rapid-fire equipment had to have zero initial tension. This meant no pressure between turns at no load. In addition, the springs were required to have a constant stacking rate . . . deflect proportionately for each equal load addition and have close tolerances.

Springs of Armco 17-7 PH wire, formed by the same method as standard extension springs, were found to have these essential properties after one simple heat treatment. And they proved lowest in cost. The only other spring that did the job cost 5 times as much as the 17-7 PH springs.

Versatile Spring Wire

Besides high load capacity and dimensional stability, Armco 17-7 PH Stainless Steel wire offers excellent resistance to heat and corrosion. Mechanical properties and modulus of elasticity are generally comparable to music wire.

Armco 17-7 PH is supplied in round or flat wire, in bars, sheets, strip and plates. A companion precipitation-hardening grade, Armco 17-4 PH, is produced in bars and wire.

One of these special Armco Stainless Steels may prove to be the most economical answer to your product-problems. Let us send you complete information. Just write us at the address below.

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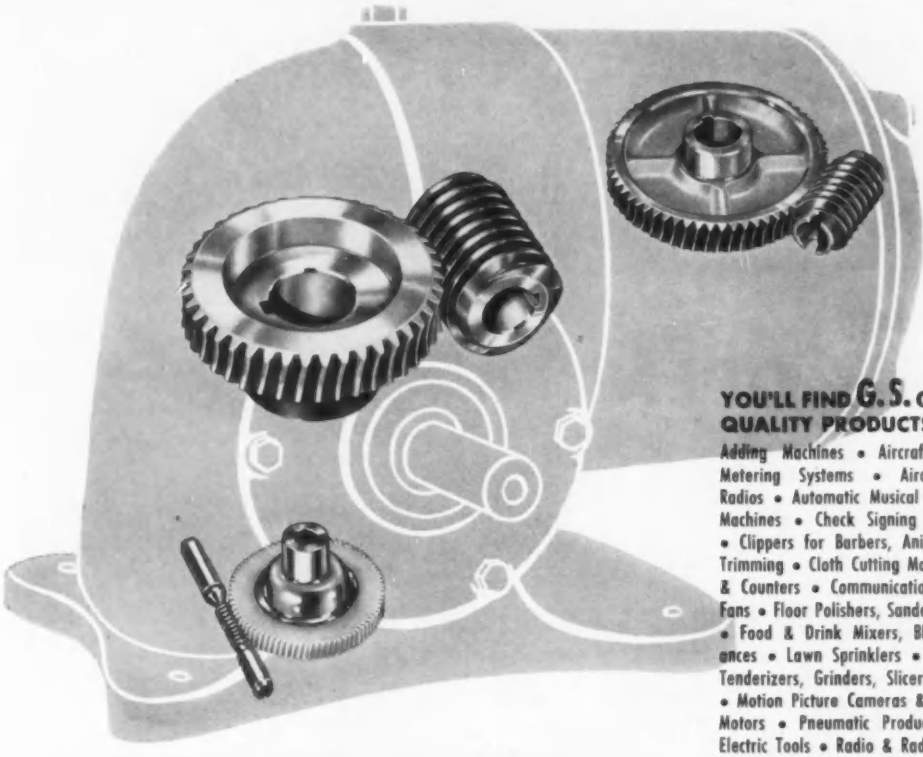

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Adding Machines • Aircraft Carburetors & Fuel Metering Systems • Aircraft Instruments and Radios • Automatic Musical Instruments • Business Machines • Check Signing & Protecting Machines • Clippers for Barbers, Animal Shearing & Hedge Trimming • Cloth Cutting Machines • Coin Changers & Counters • Communication Equipment • Electric Fans • Floor Polishers, Sanders, Scrubbers, Sweepers • Food & Drink Mixers, Blenders • Home Appliances • Lawn Sprinklers • Machine Tools • Meat Tenderizers, Grinders, Slicers • Military Equipment • Motion Picture Cameras & Projectors • Outboard Motors • Pneumatic Production Tools • Portable Electric Tools • Radio & Radar Tuning Assemblies • Radio Anti-backlash Gears • Record Changers • Sewing Machines • Steel Strap Stretchers • Step Switches • Tapping, Drilling & Threading Equipment • Telephone Dials • Television Sets • Thermostatic Controls • Typewriters • Vending Machines • Washing Machines.

ELECTRIC MOTORS RUN SMOOTHER.. LONGER..MORE DEPENDABLY..WITH G. S. SMALL GEARING

G.S. GEARING adds extra years of perfect performance to many electric motors. Extreme UNIFORM accuracy is the priceless ingredient that makes this finer Gearing outsell, outlast and outperform all others.

Motor makers as well as manufacturers of many other fine mechanical products use G.S. Small Gearing year after year. They depend upon us implicitly to keep assembly lines rolling continuously and at low cost. You'll profit, too, by coming to "Headquarters" for all the Small Gearing you need. Let our skilled engineers help you. Ideas, suggestions, and cost estimates do not obligate you. Write today!

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WORLD'S LARGEST EXCLUSIVE MANUFACTURERS OF FRACTIONAL HORSEPOWER GEARING

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40 Years of Specializing in Small Gearing!

One-quarter turn . . .

CLOSED

One-quarter turn . . .

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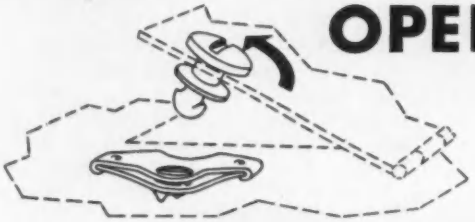
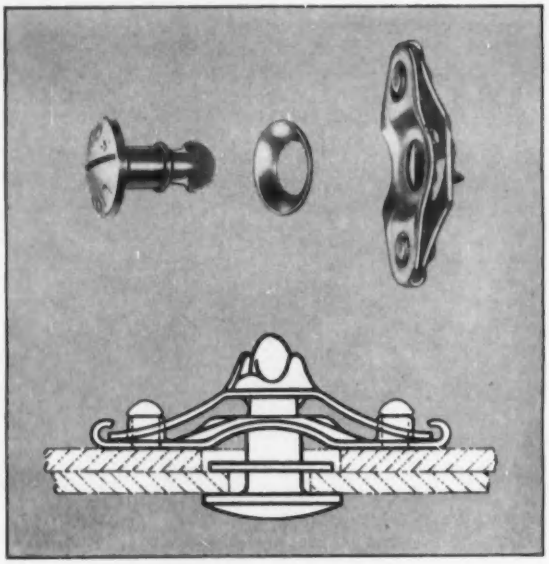




LION *QUARTER-TURN* FASTENERS

QUICK TO INSTALL

Lion Fasteners can be installed rapidly. Studs simply slip through drilled hole and are retained by a grommet. Springs are riveted or spot-welded in place.

RUGGED

Lion Fasteners stand up under the most rugged conditions of shear, tension, and vibration . . . meet or exceed the exacting requirements of Army-Navy-Air Force Specifications MIL-F-5591A (ASG) and have Civil Aeronautics Administration approval for civilian aircraft use.

LIGHTWEIGHT

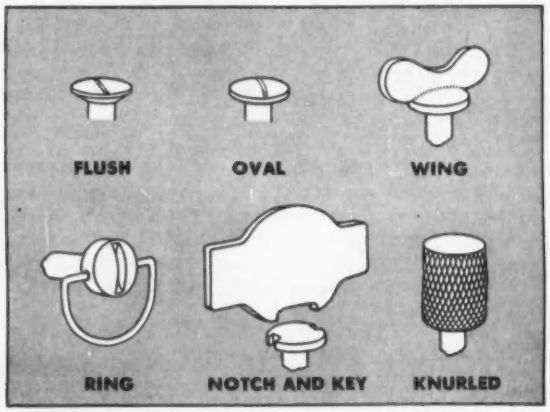
Made of cadmium-plated steel to provide a high strength-low weight ratio, No. 5 Fasteners weigh only 12 to 14 lbs. per 1000 . . . No. 2 Fasteners 3¾ lbs. per 1000 . . . No. H Fasteners approximately 35 lbs. per 1000.

VIBRATION-PROOF

This group of fasteners is particularly suited to metal fastening conditions where vibration is an important factor. Lion Fasteners can't shake loose . . . can't open by themselves.

FULL RANGE OF HEADS...

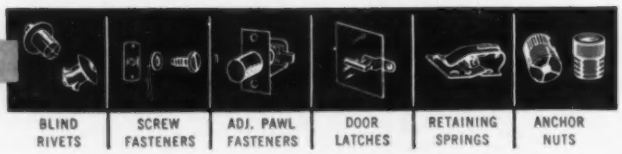
The Lion No. 5 Fastener is available with flush, oval, ring, wing, knurled, or notched head and key; No. 2 Fastener is available with flush, oval, or wing type head; the No. H Fastener comes with an oval head.



LION *Aviation* FASTENERS

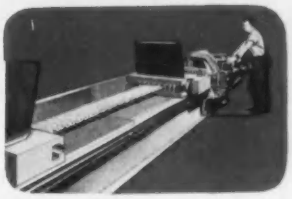
one of the ® SOUTHCO FASTENERS

For complete information on Lion Quarter-Turn Fasteners, as well as on the complete Southco line, write today to Southco Division, South Chester Corporation, 236 Industrial Highway, Lester, Pa.

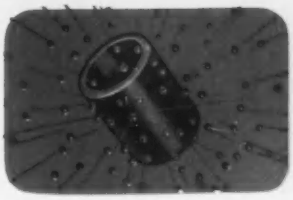


©1956

LOCK-TYPE BUSHINGS (applied on a range of sizes) end a common cause of stiff chain.

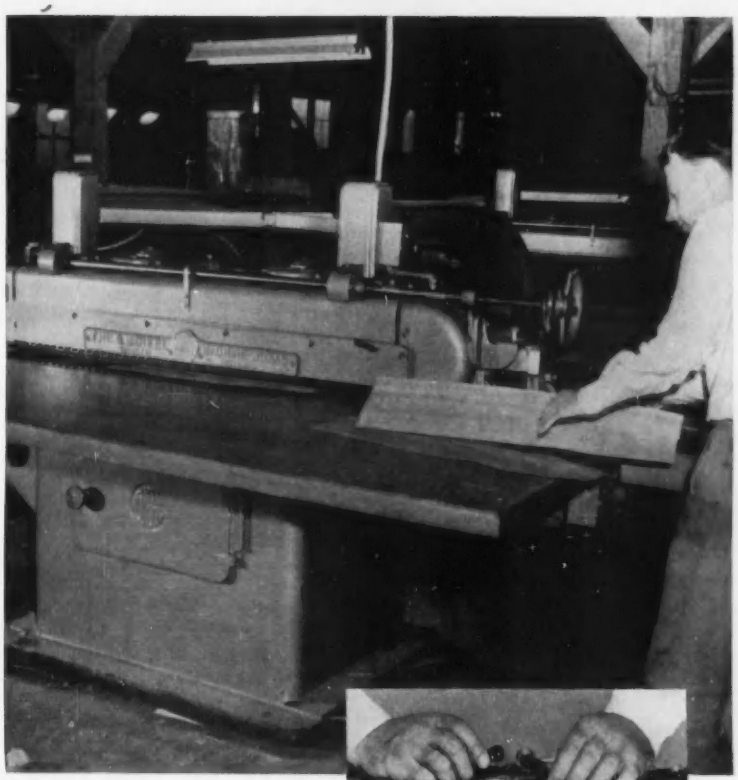


PRE-STRESSING of multiple width chain provides uniform load distribution.



SHOT-PEENED ROLLERS have greater fatigue life, added ability to withstand impact.

How these LINK-BELT EXTRAS make roller chains last longer



Feed chain on this Model 890 tapeless veneer splicer made by the G. M. Diehl Machine Works, Inc., Wabash, Ind., is Link-Belt Roller Chain. Machine joins the edges of veneer strips from 1/64 to 3/16 inch thick in one simple operation at speeds up to 85 fpm.

THERE's more to roller chain than just the parts you see. *Much more!* There are the hidden extras—standard on Link-Belt Precision Steel Roller Chain—that add up to longer life and lower costs.

Throughout every stage of manufacture, Link-Belt takes *extra* care to build *extra* life into Precision Steel Roller Chain. Shown above are three of these added refinements . . . and there are many others which contribute to better performance and longer life for your machines.

There's complete application information on roller chains in 148-page Data Book 2457. Ask your nearby Link-Belt office for your copy.

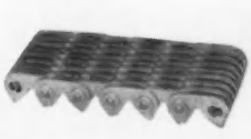
You can choose from a wide range of Link-Belt roller chains and sprockets. In addition, Link-Belt's complete line includes silent chain drives . . . and all sizes and types of cast, combination, forged and fabricated steel chains.

LINK-BELT

CHAINS and SPROCKETS

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office: New York 7; Canada, Scarboro (Toronto 15); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World. 14,030

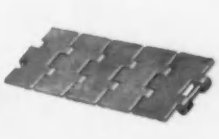
No one chain serves every purpose . . . get the RIGHT one from Link-Belt's complete line



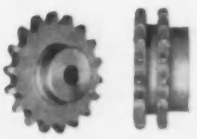
Silent Chain

LXS Steel Chain

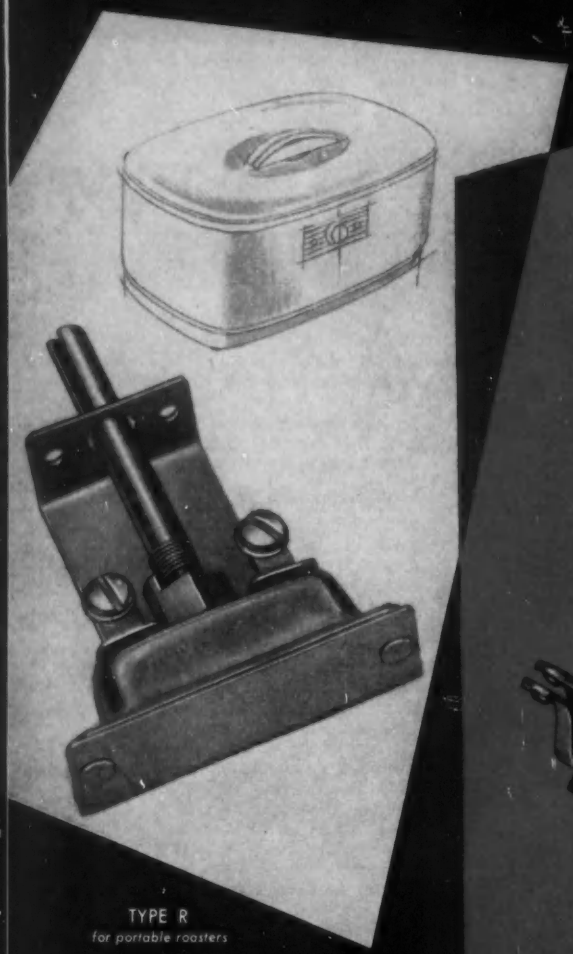
Detachable Steel Link-Belt



S-815 Flat-Top Chain

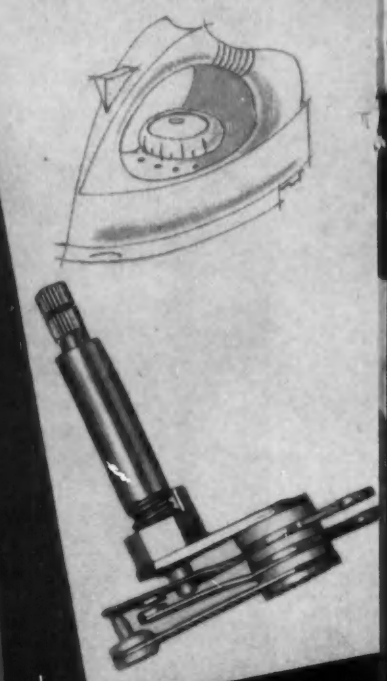


Cast and Cut-Tooth Sprockets



TYPE R
for portable roasters

TYPE SA
for automatic percolators



TYPE S
for steam or dry irons with multiple heats

THERMOSTATS

to whet a designer's imagination . . .

With competitive conditions ahead, you're probably reappraising your product. Or designing a new one. Either way, with Stemco thermostats on the job there's every chance you'll improve performance . . . solve production headaches . . . lower costs.

No other line of bimetal thermostats has as many different styles in production. So if you want close control, compactness, light weight—you'll find them all in Stemco thermostats. Combined with Stevens application engineering service, you profit from important savings of being able to use a production line Stemco thermostat for your special needs.

Let's match our experience and enthusiasm against an hour of your time. A card or call will bring our representative on the double.

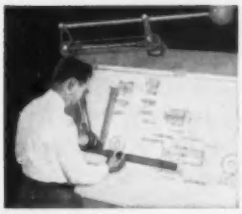
STEMCO thermostats

sensitive • close control
quick acting • positive acting
snap acting • shock resistant
light • compact • adjustable
non-adjustable
open type
hermetically sealed

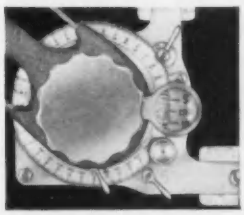
STEVENS manufacturing company, inc.
Mansfield, Ohio

"And I Said I'd Never Use a Drafting Machine"

"That Was Before I Tried a Bruning Equipoise Drafter!"



Bruning Counterbalanced Drafters and Bruning Track Drafters provide fast, easy, accurate drafting on vertical boards and on extra-large drawings.



Bruning Equipoise Drafters are available with either the Civil Engineer protractor head, shown here, with its special azimuth scale, or the Standard protractor head.

Take a tip from an increasing number of draftsmen who, perhaps like yourself, were reluctant to try any drafting machine or had been disappointed in a conventional type drafter. These men now report: Bruning Equipoise Drafters cut drafting time over conventional equipment up to 40% on most jobs, up to 50% on some structural drawings — beat any other drafting machine they ever tried.

But prove it to yourself! See how fast you'll work with one precision instrument combining T-square, straightedge, triangle, protractor, and scales. Feel how the patented Equipoise mechanism eliminates any drift from gravity, literally makes the drafter "float" into place. Find how easy it is to rotate, turn, and lift this drafter — all with the left hand. At the same time, operate the Touch Control button with your left thumb to set the drafter automatically at any of 24 commonly used 15-degree increment angles. Don't overlook the special scale lock that makes it easy to change the scales, holds the scales rigid.

Your own test will convince you of the superiority of a Bruning Equipoise Drafter. Mail coupon today!

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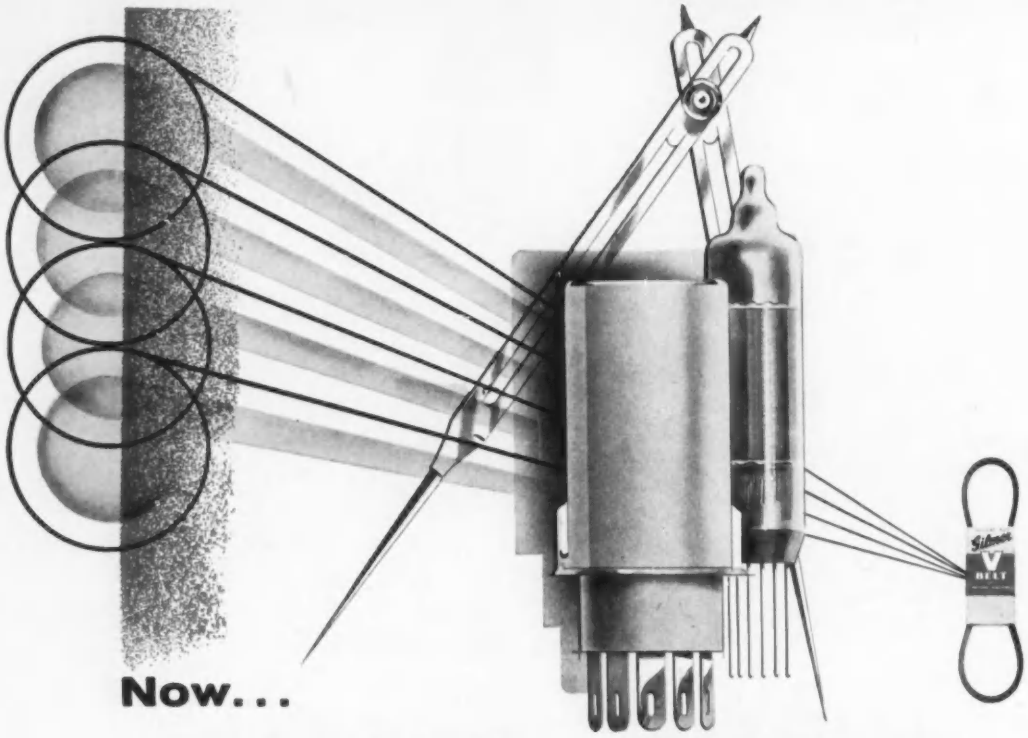

Now...

ELECTRONIC TENSIONING

latest development in the continuous perfecting of Gilmer V-BELTS

ELECTRONIC TENSIONING—brought to you by Gilmer—is today's biggest innovation in V-belt construction...your assurance of more dependable pulling power and longer service life!

In the manufacture of most V-belts, the cord section is wound with a *mechanical* device which attempts to regulate the tension. Gilmer V-Belts used to be made this way, too...until Gilmer engineers recently perfected a new kind of tensioning device regulated by error-proof *electronics!* This assures scientifically accurate distribution of the belt's load to every strand of its cord section.

Electronic Tensioning is the latest in a series of constant improvements in the construction of Gilmer V-Belts, many of which owe their origin to Gilmer's successful development of the "Timing" Belt. That is why you can be confident that the V-belts you buy today from your NYB&P-Gilmer Distributor embody the most advanced materials and manufacturing methods to give you maximum performance and service life.

Gilmer

V-BELTS AND "TIMING®" BELTS

NYB&P INDUSTRIAL RUBBER PRODUCTS

NYB&P — NEW YORK BELTING & PACKING CO. founded 1846

NEW YORK BELTING & PACKING CO. 1 Market St., Passaic, N. J.

America's Oldest Manufacturer of Industrial Rubber Products

Here's the Complete "Package"

for Counting Electrically...

Added Evidence that —

Everyone Can Count on VEEDER-ROOT

This Veeder-Root Reset Magnetic Counter (AC or DC) is actuated through electromagnets. And it may be connected in series with any device having a contact arrangement . . . like the specially designed Veeder-Root Electrical Contactor at the left, which insures positive operation of the counter, either in oscillation or connected directly to a revolving shaft . . . with the counter placed at *any* distance from the machine or process on which the count is required.

This is another one of the hundreds of Veeder-Root Standard and Special Counting and Computing Devices developed for every conceivable counting duty, in every field from atomics to electronics.

What do *you* need to count? Just write:

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Chicago 6, Ill. • New York 19, N. Y. • Greenville, S. C.
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Offices and Agents in Principal Cities
"The Name that Counts"

Craftsmanship of the 20th Century

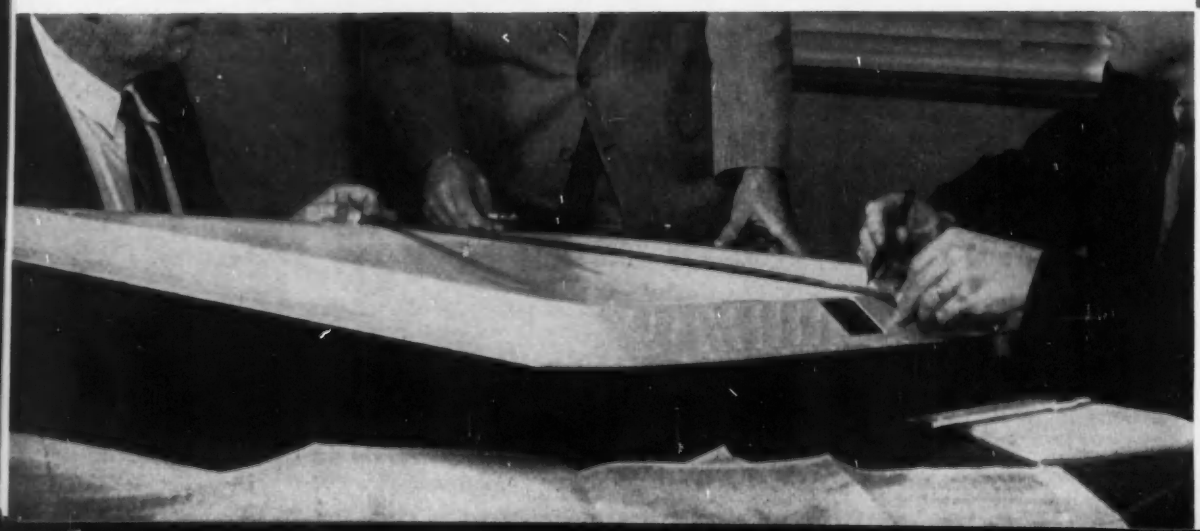
MONSANTO

Designers constantly face the challenge of making next year's products more serviceable, more salable. More and more of them are working out their problems with the assistance of plastics engineers. This picture-story tells how craftsmen of the custom molding industry helped utilize the unique properties of plastics in the fabrication of an important refrigerator component. Perhaps custom molders can contribute to solving your design problems in the same way.

How custom molding and Lustrex Styrene solved a complex Westinghouse design problem...

DESIGN OBJECTIVES called for providing additional storage facilities in a new line of refrigerators. Westinghouse designers drew up plans for incorporating egg racks, butter and cheese compartments, shelf pockets, etc., in the door. The liner Westinghouse visualized had to function as a structural member of the door. It also had to conform to the new trend toward color and be produced within strict cost limits. The design raised engineering questions which focused on material specifications and production methods.

MATERIAL SPECIFICATIONS for the door liner stressed outstanding "formability" to minimize assembly problems. The material had to be hygienically smooth and stain resistant, have high gloss and meet specific color requirements. It had to have great impact strength, moisture and warp resistance, and a low thermal coefficient of expansion and contraction. In addition it had to have sufficient tensile strength to withstand the cross-sectional stress imparted by one side hanging on two hinges. The search for a material with these combined properties narrowed down to a modified styrene plastic (a material which had already proved its qualifications in Westinghouse trays and beaker strips).



PRODUCTION of the door panel required a mold designed to impart a cross-section wall thickness that had to vary precisely in increments of thousandths of an inch over an area of 2,250 square inches. This permitted molding the basic piece from a single sprue, yet provided an efficient flow pattern with minimum amount of styrene displaced in the cavity. Dies were designed and built by Major Mold and Die Co., Detroit, for injection presses of the 400-oz. capacity range.

PERFECTED DOOR LINERS are molded of Monsanto Lustrex high impact styrene. Despite new advantages of glamorous appearance and rugged durability, material cost averages lower than for materials previously used. The soft color tones (blue, green, beige and white) are permanently infused into the molded piece, eliminating costly refinishing and

assembly steps, while adding functional sales appeal to this popular Westinghouse product.

This is one of hundreds of design and production problems which have been solved by utilizing the facilities of the plastics custom molding industry. These 20th Century craftsmen are available to manufacturers designing for greater efficiency and lower costs. As a major supplier of styrene and other plastics, Monsanto is in a position to introduce you to custom molders who will put their knowledge and skills to work for you. If you are considering a design change for your product line, be sure to investigate plastics. Write to Monsanto Chemical Company, Industrial Applications Dept., Springfield 2, Mass.

Custom molding companies assisting in the development and molding of this large door liner include Amos Molded Plastics Co., Bridgeport Molded Products, General American Transportation Co., General Machine & Tool Works, Prolon Div. of Pro-phy-lac-tic Brush Co., Worcester Molded Plastics Co. In addition, some of the liners are molded by Westinghouse at their Columbus, Ohio, plant.

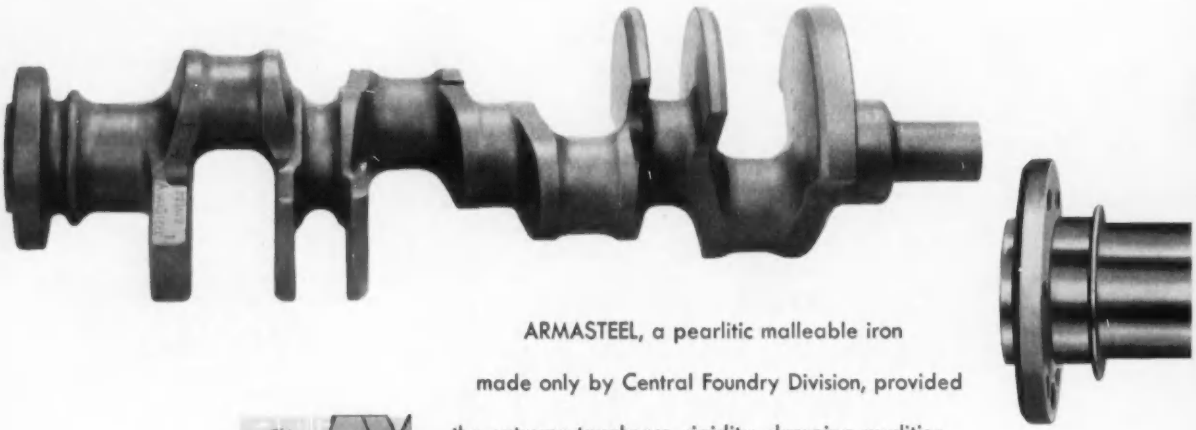
Investigate Monsanto's completely balanced line of styrene formulations developed for particular applications and sold under the trade name . . .

LUSTREX
Styrene Plastic

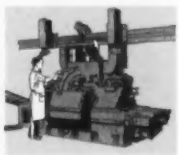
MONSANTO

the step-by-step story of how ARMASTEEL shell-cast crankshafts saved machine time, tools, and labor for Pontiac Motor Division

After hundreds of hours of research and experimentation, the Pontiac Motor Division in 1955 began installing *cast* crankshafts in their automobiles, and in 1956 have completed a 100% conversion to castings. It was because of the combination of Central Foundry Division's amazing material, ARMASTEEL, combined with the new shell mold process that made this switch-over to cast crankshafts practical and profitable.



ARMASTEEL, a pearlitic malleable iron made only by Central Foundry Division, provided the extreme toughness, rigidity, damping qualities and all the other physical properties necessary for better crankshafts. And the superior machining characteristics of ARMASTEEL plus the close dimensional tolerances of the shell mold process made possible the substantial savings from one end to the other of the crankshaft finishing line. Take it step by step . . .



1

THE FIRST STEP IN MACHINING cast crankshafts at Pontiac is the milling of the driving pads. Where formerly they processed 80 steel crankshafts an hour on these milling machines, production has now been increased to 96 an hour on the ArmaSteel parts. A similar increase has been noted in tool life . . . during a two-week period of machining steel crankshafts, 336 cutters had to be ground, while in a two-week period when the crankshafts were ArmaSteel, only 153 cutters needed grinding.

2

SECOND STEP IN THE PROCESS is the turning of all in-line diameters on crankshaft lathes. Here, it was found that the superior machineability of the ArmaSteel parts allowed lathe speed to be increased from 53 R.P.M. to 153 R.P.M., and that the rack-to-rack cycle time reduced from 2.75—3.00 minutes to 1.40—1.50 minutes, thus doubling output.

3

THIRD STEP is the rough grinding of main journals. Where steel forgings were ground at the rate of 32.5 per hour, 45 ArmaSteel cast crankshafts are being processed per hour. Grinding wheel life is substantially increased.

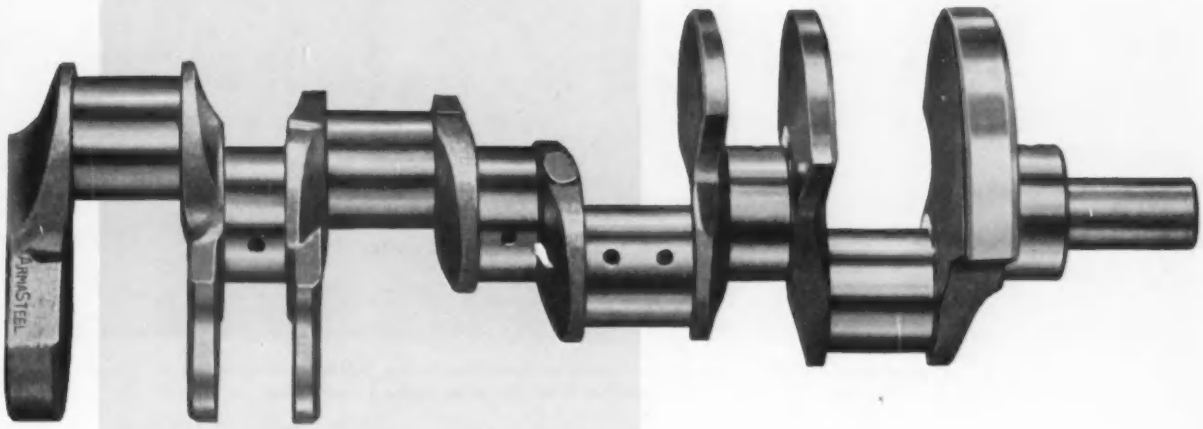
4

FOURTH STEP involves the rough turning of crankpins. Production has been speeded here from 24 steel parts to 46 ArmaSteel parts per hour, due partly to decreased stock to be machined.

6

THE REMAINING OPERATIONS INCLUDE oil-hole drilling, finish grinding on main journals, straightening, and tapping of holes in the flywheel flange. In drilling oil holes, production men found that the need for retracting drills periodically for chip removal was eliminated by ArmaSteel. This helped speed output from 37.5 steel to 64 ArmaSteel parts per hour. Drills needing to be reground or replaced were only about ¼ as many with the cast crankshafts. One transfer drilling line has been discontinued, which allowed the elimination also of one lathe for turning OD of counterweights, and one straightening press, both of which were automated with the drill. Less straightening is necessary on the ArmaSteel castings, and finish grinding on main journals is faster than with steel. A greatly reduced number of taps are used in tapping the flywheel flange holes.

THUS, MACHINE TIME, TOOLS, LABOR, and long-range capitalization have all been decreased through the change to shell-cast ArmaSteel crankshafts. Performance of the part is excellent, and many new design possibilities have been opened up. This is likewise true of many other products that have taken advantage of ArmaSteel and Central Foundry Division's shell mold process. For information on how your product can also benefit, write today for your copy of the "ARMASTEEL" catalog and pamphlet "Shell Molding at Central Foundry".



5

FIFTH STEP is finish turning on the crankpins. Production has been more than doubled on this operation. Where 21 steel crankshafts per hour were processed, 46 of ArmaSteel are being turned.

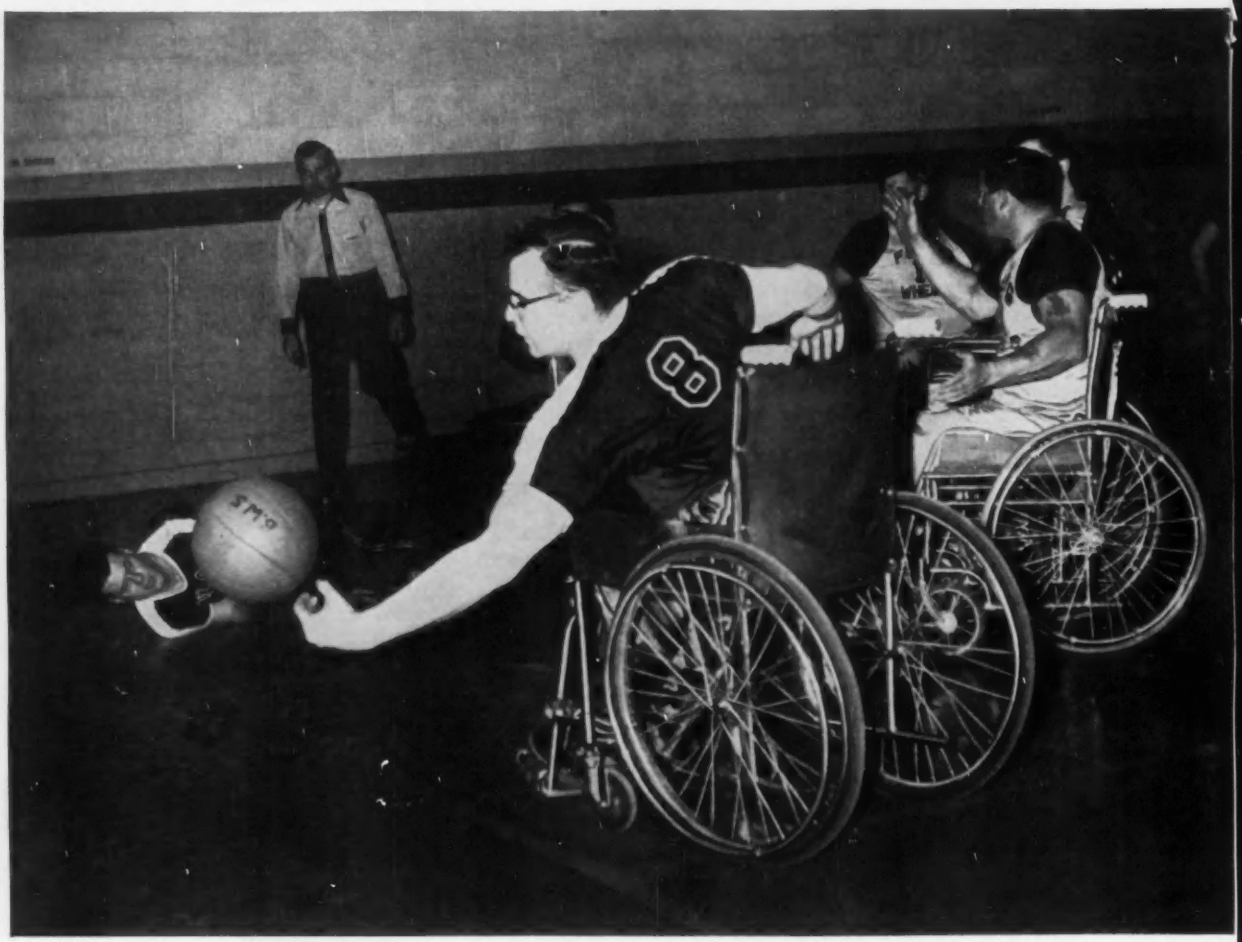
CENTRAL FOUNDRY DIVISION

GENERAL MOTORS CORPORATION • SAGINAW, MICHIGAN • DEPT. 10

67

WHEN IT'S *MOVING*...MAKE IT *TUBING*

Pound for Pound, Tubular



Wheeled chairs get stiff workouts in fast-moving paraplegic basketball. Tubular construction keeps them strong, safe, maneuverable. When it's moving, make it steel tubing.

REPUBLIC

REPUBLIC STEEL

World's Widest Range of Standard Steels

Construction is STRONGEST!

At any given weight, tubing is strongest of all mechanical shapes . . . stronger under compressive load . . . stronger as a beam . . . stronger in torsion.

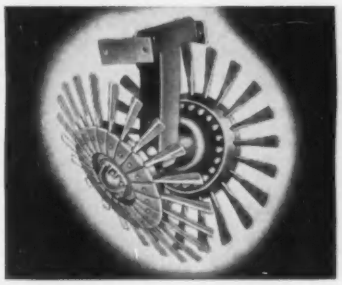
And, dollar for dollar Republic ELECTRUNITE Steel Mechanical Tubing is your best buy. ELECTRUNITE is the original electric resistance welded tube. It's the quality tube of industry, available in a wide variety of forms, sizes and gages . . . in both carbon and stainless steel.

For volume production, ELECTRUNITE tubing is consistently uniform, foot to foot, shipment to shipment. It offers uniform wall thickness and concentricity. Surfaces are free from scratches and pit marks. It offers uniform response to heat treatment. It is easy to fabricate . . . often eliminates some costly fabricating or machining operations.

When your product must be strong, safe, lightweight, investigate Republic ELECTRUNITE Steel Tubing. Republic engineers can help you design it into your products and processes, economically and profitably. Send coupon for facts.

MORE REPUBLIC PRODUCTS MADE FOR MOVEMENT:

"I PUT REPUBLIC NYLOK NUTS TO THE TEST e. ..ry time I ride my Taylor Tot," reports this young test driver. In spite of all the bumps, bounces and jolts, Nylok Nuts always hold tight. The reason: a special Nylon plug that assures positive locking in any position wherever you stop wrenching. Send coupon for details.



THESE BEET DIGGER TINES ARE 24% STRONGER since John Deere switched to alloy steel. Originally fabricated from carbon steel, they would sometimes break under stress. By taking advantage of alloy's hardenability—plus superior strength—bending and abrasion problems have been eliminated. Send coupon for complete data on Republic Alloy Steels.

DOUGLAS AIRCRAFT ADDED A PASSENGER—AT NO INCREASE IN WEIGHT on their new DC-7 superliner. How? By substituting Titanium for other metals normally used in nacelle construction. Republic is an old hand at this high strength-to-weight business. Send coupon for information on how Republic Titanium and Titanium Alloys may help your product.

STEEL

and Steel Products

REPUBLIC STEEL CORPORATION
Dept. C-1249
3150 East 45th Street
Cleveland 27, Ohio

Please send me more information on:
☐ ELECTRUNITE® Mechanical Tubing ☐ Alloy Steels
☐ NYLOK® Nuts ☐ Titanium
®U. S. Pat. Nos. 2,450,694 and pending applications.

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Company_____

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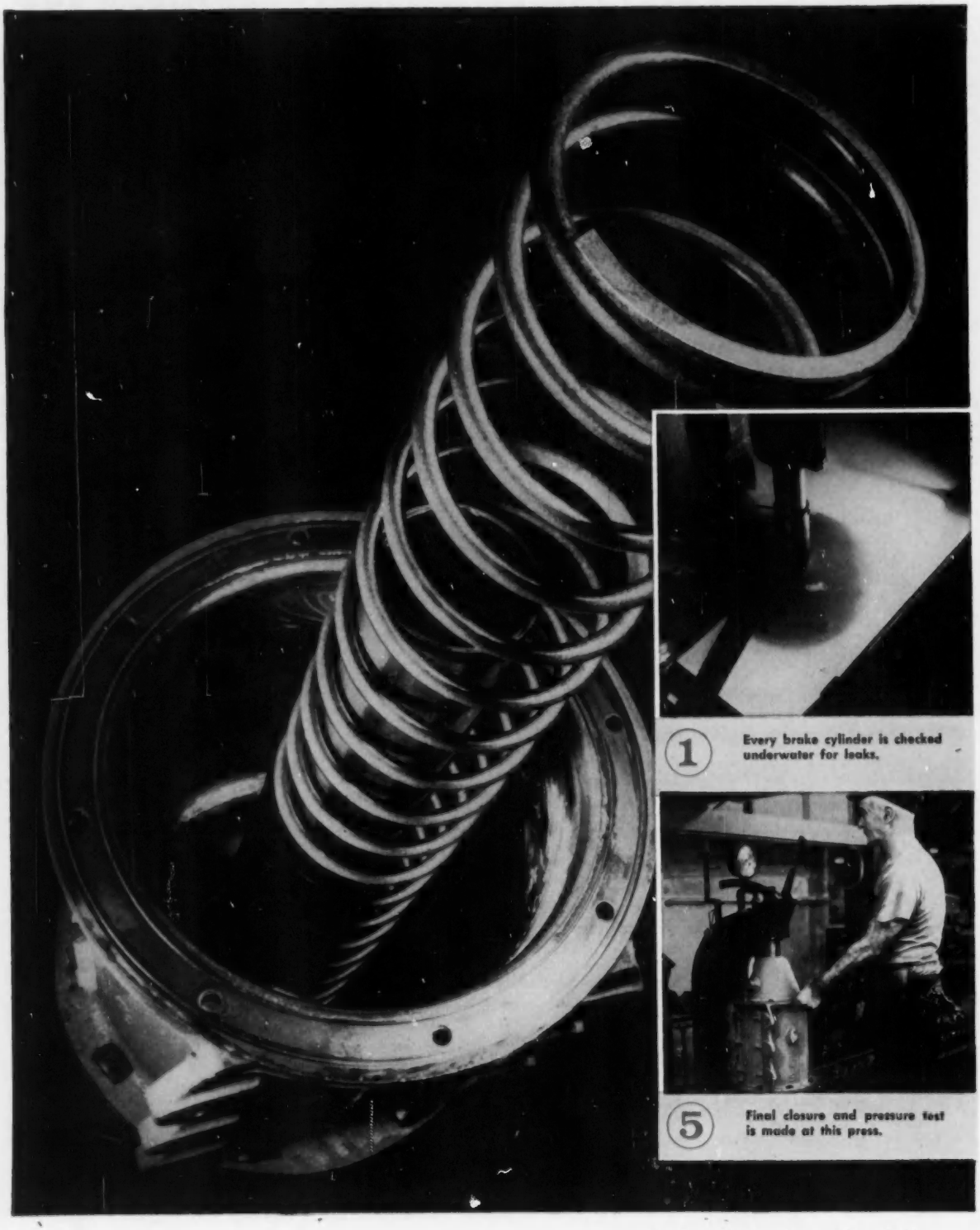
Inside story of the most



1 Every brake cylinder is checked underwater for leaks.

5 Final closure and pressure test is made at this press.

famous brake in the world

Even schoolboys know the fabulous story of George Westinghouse, and how he accelerated developments of railroad transportation with his Westinghouse Automatic Air Brake. Even if a train breaks in two, brakes are applied to *each* section to stop it.

Although Westinghouse Air Brake Company has made countless improvements in braking devices, the basic operating principles have prevailed since 1872. Original design of some parts is still followed today, that's how well they were designed in the first place.

A good example is the release spring, which retracts the brake cylinder piston when the brakes are released. American Steel & Wire has been supplying this spring for about 75 years. And although better steels and heat treatment are always being used, this original spring design has been operating over a 160° F. temperature range, stressed hundreds of times monthly, and is currently in service on over 2 *million* freight cars all over the world.

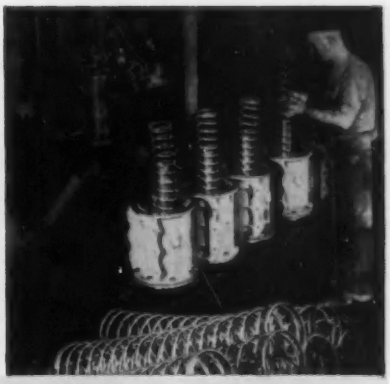
We are proud of our long association with Westinghouse Air Brake Company, maker of the most famous brake in the world, considered by many people to be one of the great inventions of our time.

AMERICAN STEEL & WIRE DIVISION, UNITED STATES STEEL, GENERAL OFFICES: CLEVELAND, OHIO
COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO, PACIFIC COAST DISTRIBUTORS
TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA., SOUTHERN DISTRIBUTORS
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

USS AMERICAN QUALITY SPRINGS

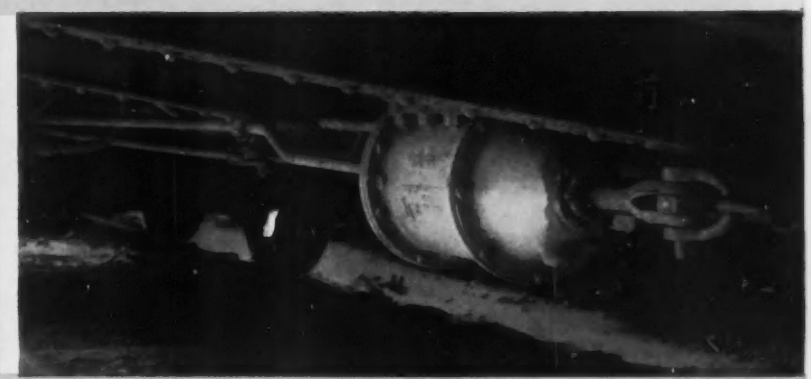
2 Piston assembly. Westinghouse Air Brake Company makes its own rubber parts.

3 After piston is inserted, workman lubricates the cylinder.



4 Spring inserting. The housing is machined high-density cast iron.

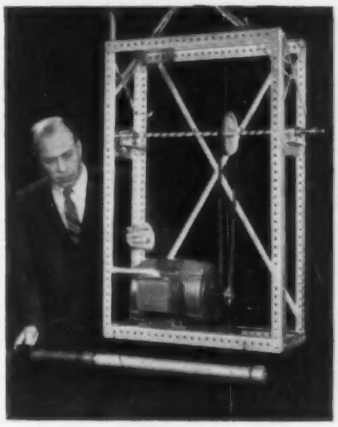
6 Cylinder at left is for freight cars, other is one of several used on a locomotive.



7 In position. Cylinders go three years between cleanings.

USS

UNITED STATES STEEL



TOMORROW:

A standard motor that can survive infinite heat

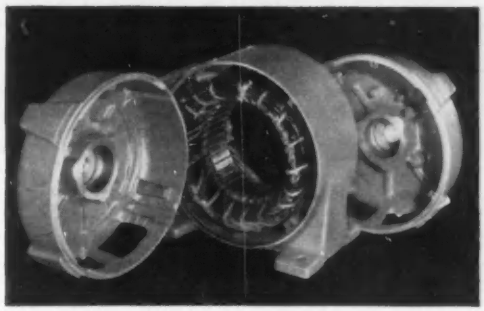
The new Life-Line A is another step closer

Westinghouse is working on tomorrow's motor today. Investigating new materials—testing existing motor designs.

No standard motor today can survive the ultimate test shown here. But we do know that the new Life-Line® "A" can operate under higher temperatures than ever before. It has stronger insulation and better bearing protection than any other motor on the market. It's industry's closest approach to a standard motor that is absolutely heatproof.

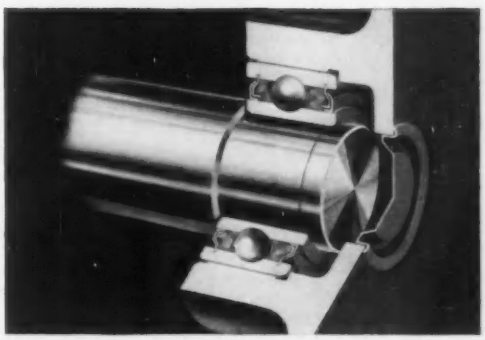
Your Westinghouse sales engineer can show you many additional reasons why the Life-Line "A" is industry's most advanced and preferred motor. Call him today.

J-21926



New fortified insulation includes exclusive Bondar, Bondite and Mylar*—three good reasons why the Life-Line "A" is so resistant to heat or any other motor contamination.

*DuPont Registered Trade-Mark



Two outer seals of new 4-way sealed bearing act as flingers and literally throw off damaging contaminations. Inner seals, attached to outer bearing race, are stationary and form a positive labyrinth.

WATCH WESTINGHOUSE!

WHERE BIG THINGS ARE HAPPENING TODAY!

MUELLER BRASS CO.
improves LENSOMETER
lower cost

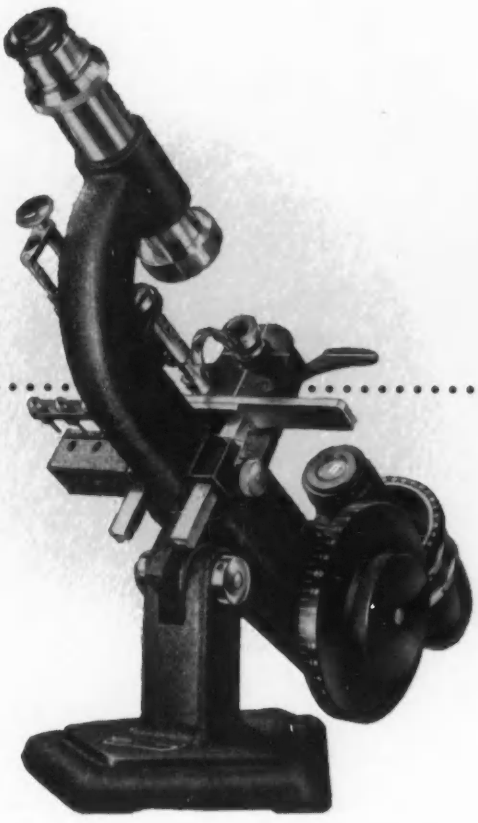
FORGED PART APPROXIMATELY ½ SIZE

Precision and extreme accuracy are vitally important functions of the Lensometer, manufactured by the Instrument Division of the American Optical Company, Buffalo, N. Y. The Lensometer is used to determine the focal strength and axis of an optical lens and, consequently, must be extremely precise in operation to provide accuracy and uniformity in lens prescriptions.

Forgings made by the Mueller Brass Co. play an important role in the construction of the Lensometer and contribute to its outstanding performance. Formerly, the body of the Lensometer was produced from three sand castings, but these now have been replaced by just two forgings. Naturally, this simplifies assembly, and the big forged bronze main support arm, shown above, along with the lens support bracket insures the constantly accurate alignment of the instrument. During the first year when forgings were used instead of castings, American Optical not only recovered the initial tooling costs but also realized considerable savings on each Lensometer produced. This is another good example of the way Mueller Brass Co. forgings can benefit a product two ways . . . better performance and lower costs. Chances are, your product can likewise be improved at a savings to you if you specify brass, bronze or aluminum forgings made by the Mueller Brass Co.

FORGING

at substantially



• WRITE TODAY FOR THE ENGINEERING MANUAL YOU NEED

Mueller Brass Co. Forgings Engineering Manual H-58565 ☐

Tuf-Stuf Aluminum Bronze Alloys Engineering Manual H-58563 ☐

600 Series Bearing Alloys Engineering Manual FM-3000 ☐

Copper Base Alloys in Rod Form Engineering Manual FM-3010 ☐

METALS AND ALLOYS REVIEW

by FRANK M. LEVY

Vice-President and Director of Research

One of our most interesting series of alloys is the group which we market under the tradename "Tuf-Stuf" . . . a group of aluminum bronze alloys with range and flexibility to meet the most demanding needs. They are high copper base alloys containing from 9% to 13% aluminum and varying amounts of iron, nickel and manganese. Being free of zinc, they are not subject to dezincification. Tuf-Stuf alloys have a low coefficient of friction, good wearing qualities, high tensile strength, high hardness and the ability to withstand heavy pounding. Some of the alloys can be hardened by heat treatment. In the harder grades, these alloys are used for heavy duty service where high compressive loads are encountered and where lubrication may be scant. Present day increases in operating speed of modern machine equipment and the economy of little or no machine "down" time has made Tuf-Stuf popular in the machine tool industry. It is used in a multitude of applications where resistance to wear is important, such as: Drill Jigs, Feed Nuts, Rollers, Cams, Collets, Gibs, Gears, Boring Bar Guides, Lead Screw Nuts and Clutch Shifter Forks. Also, because of their ability to withstand higher stresses and resist season-cracking, these alloys are ideally suited for threaded nuts and bolts and pole-line hardware.

The unusual physical properties of the Tuf-Stuf series have made it particularly useful in the chemical and allied industries. These alloys combine the strength and ductility of medium steel with high resistance to corrosion by many chemicals. Tuf-Stuf alloys will not only resist oxidation at elevated temperatures, but will also retain a greater portion of their strength and hardness at these temperatures than will the copper zinc alloys. These properties make them ideal in the aircraft industry for valve seat inserts, spark plug bushings, valve guides and propeller hub cones.

Tuf-Stuf alloys are supplied as forgings, rod or screw machine products. As forgings the grain structure can be controlled to produce parts that are strongest at points of greatest stress and strain. Relatively intricate shapes can be forged to closer tolerances than sand castings. Where appearance is a factor, a forging may easily prove more economical since a minimum amount of machining, buffing or polishing is required before finishing.

If you'd like more information about this series of alloys, drop me a line or better yet, send me your sample part or blueprint and an explanation of its use and we'll be glad to submit our recommendations.

MUELLER BRASS CO.

PORT HURON 17, MICHIGAN

178

NO MOTOR BURNOUTS

in Bell & Gossett Booster Pumps...

They are Protected with KLIXON Inherent Motor Protectors

Bell & Gossett, foremost manufacturer of quality, long life booster pumps, knows the value of KLIXON Inherent Overheat Motor Protectors . . . knows from experience how KLIXON Protectors guard against motor burnouts, and add to the dependability of the pumps.

Here's what the latest B&G Sales Bulletin has to say about KLIXON Protectors —

"PROTECTED AGAINST MOTOR BURN-OUT

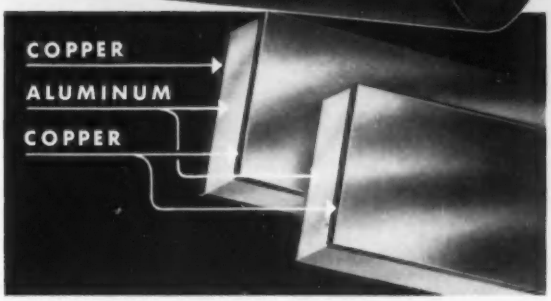
The B&G Booster Motor is protected against both usual and unusual causes of failure. Modern, efficient thermal overload equipment shuts off the motor should a dead-stall be caused by foreign matter in the pump, or if low voltages should cause the motor to overheat.

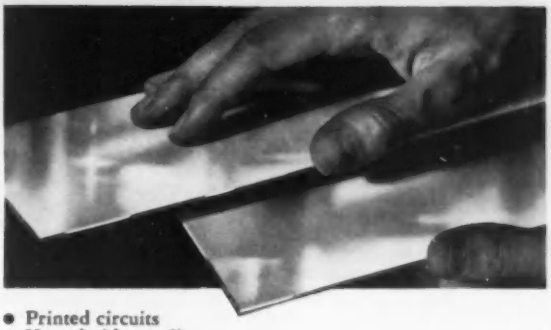
"If for any of the above reasons the motor should stop, it will automatically try to start after a short interval. It will continue to stop and start until the cause of the overload is removed. The operation of this protective device is not harmful to the motor."

You, too, can keep motor-driven equipment operating dependably by specifying and using KLIXON protected motors. They reduce maintenance costs, service calls, repairs and replacements. The additional cost is low . . . with exceptionally worthwhile benefits for everybody concerned.

KLIXON®

METALS & CONTROLS CORPORATION
SPENCER THERMOSTAT DIVISION
905 FOREST STREET, ATTLEBORO, MASS.





...and General Plate Division

ALCUPLATE®

(Copper clad aluminum)

is a case in point

CUTS COPPER COST BY 15 TO 30%
CONSERVES CRITICAL COPPER

ALCUPLATE, made by permanently bonding solid copper to one or both sides of less expensive aluminum, has virtually the same physical and electrical properties as solid copper — at much lower cost.

ALCUPLATE can be stamped, drawn, or formed in a work-hardened state — without annealing — and the copper provides an ideal surface for soft soldering or electroplated finish. This permits fabrication of many parts and products, at savings of 15% to 30% over solid copper.

Here are typical products in which ALCUPLATE is now saving money:

- Electrical terminals, clips and shims
- Small motor housings
- Electronic component cases, cans, brackets, and chassis
- Heat transfer assemblies
- Fin and tube-type radiators
- Printed circuits
- Household utensils
- Costume jewelry and giftware

If you are seeking metals with useful characteristics that can't be found in a single metal or alloy — look to General Plate Clad Metals. If you want stronger or lighter components — or better electrical and mechanical properties — or fewer corrosion problems — or if you are interested in conserving critical metals or reducing parts costs, you should be investigating General Plate Clad Metals.

Catalog PR-700 covering base to base and precious to base clad metals, TRUFLEX® Thermostat Metals, composite electrical contact, buttons and rivets are yours for the asking. New PR-226A folder with clad metal samples also sent free. Write for it.

You can profit by using General Plate Composite Metals!

METALS & CONTROLS CORPORATION
GENERAL PLATE DIVISION
15 FOREST STREET, ATTLEBORO, MASSACHUSETTS

Where can we give you
OIL SEAL
ENGINEERING HELP?
CHICAGO 462 McCormick Bldg., HA 7-5163
CLEVELAND 210 Hts. Rockefeller Bldg., YE 2-2720
DALLAS 2520 W. Mockingbird Lane, DI 7541
DETROIT 13836 Puritan Ave., VE 6-1909
INDIANAPOLIS 2802 N. Delaware St., WA 3-1535
KANSAS CITY 4445 Terrace, LO 6622
LOS ANGELES 11634 Patton Rd., Downey, TO 2-8163
MILWAUKEE 647 W. Virginia St., BR 1-3234
NEWARK 1180 Raymond Blvd., MI 2-7586
SAN FRANCISCO-OAKLAND Redwood City, EM 6-3861
WICHITA 519 S. Broadway, AM 2-6971
AB CD EF GH IJ KL MN OP QR ST UV WX YZ

When you need a dependable source of conventional oil seals, or engineering help on new seals to meet unique conditions, call your National Oil Seal Applications Engineer. He's a specialist in seals, factory trained and a veteran at his business. Whether your seals can be shipped from stock, made from existing tools, or require new engineering, he'll give you a fast, accurate and realistic answer.

Your National Applications Engineer is backed by the productive capability of four big NMB plants, and 35 years of oil seal specialization. Call him while your new design is still on the drafting board—the best time to specify seals. His telephone number and address are listed above.

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OIL & GREASE SEALS
O-RINGS SHIMS
Product of the world's largest exclusive manufacturer of oil seals

NATIONAL MOTOR BEARING CO., INC.
Plants at Van Wert, Ohio, Redwood City, Downey and Long Beach, Calif.
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3676

DU PONT
REG. U. S. PAT. OFF.
"Better Things for Better Living ... through Chemistry"

PRODUCT ENGINEERING NEWS

PROPERTY AND APPLICATION DATA ON THESE VERSATILE ENGINEERING MATERIALS: "ZYTEL," "ALATHON," "TEFLON," "LUCITE."

No. 4, 1956

Gears and housing of ZYTEL® nylon resin permit simplified, more compact paintbrush-cleaner design

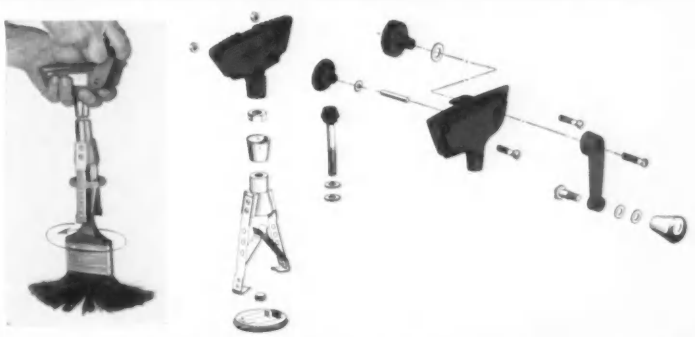


Photo of "Spin-A-Brush" cleaner in use, with exploded view showing parts of "Zytel" in red. (Parts molded by Process Gear Company and Chicago Molded Products. Manufactured by Portable Electric Tool Company, Chicago, Illinois.)

THIS hand-operated paintbrush cleaner has been designed for home or professional use. The lightweight, compactly designed unit will clean a paintbrush or paint roller in approximately ninety seconds.

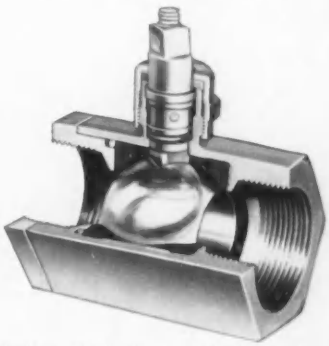
A handle actuates molded gears of "Zytel", set at a 1 to 8 ratio, which spin the brush. These smooth-operating gears of "Zytel" require no lubrication and reduce backlash considerably. A self-tapping metal screw attaches the initial gear to the handle, locking the gear securely and permanently in place.

"Zytel" nylon resin was selected for this application because it is accurately and inexpensively injection molded and requires no further finishing. The bevel gear and spur of "Zytel" mold as a unit, eliminating a costly machining and assembly operation.

The use of "Zytel" made possible an improvement in styling, in addition to substantial cost savings. The comfortable palm grip housing of "Zytel" is durable, lightweight, and impervious to ordinary solvents. Each half contains several complicated inserts, and is molded to close tolerances in one operation. The parts join neatly together without grinding. The attractive grey finish requires no polishing or buffing.

Because of its unique combination of properties, "Zytel" nylon resin does a superior job in a great variety of industrial applications. "Zytel" is distinguished by its toughness, form stability at high temperatures, and chemical resistance. Be sure to investigate Du Pont "Zytel" nylon resin. Complete property and application data are available to you without cost or obligation.

Ball valve seats of TEFLON® provide tight, long-lasting, chemically inert seals



"Double-seal" ball valve manufactured by the Jamesbury Corporation, Worcester 5, Massachusetts. Processors—Crane Packing Company, Chicago, Illinois, and United States Gasket Company, Camden, New Jersey.

WITH SEATS of "Teflon", these valves are able to handle practically all known liquids and gases—through extreme temperature ranges. They also offer the advantage of economy by reducing maintenance time.

"Teflon" tetrafluoroethylene resin is inert to all chemicals normally used in industry. Only alkali metals and fluorine under special conditions affect "Teflon".

"Teflon" is non-flammable and has zero water absorption. Its chemical inertness, heat resistance (working temperature range of "Teflon" extends from −450°F to 500°F), resiliency and toughness recommend "Teflon" for use in gaskets, packings and component parts of pumps, agitators, mixers and for valve seats and discs.

Investigate the benefits of using "Teflon" in your own applications. No other single material serves so well over such a wide range of conditions.

Flexibility of ALATHON® assures close fit, positive protection in dust masks

"Alathon" polyethylene resin plays a key part in this new paint and dust mask, which affords improved protection and comfort to both commercial and home users.

One of the major difficulties in protective masks—air leaks around the frame—has now been eliminated. The frames of "Alathon" are contoured and flexible, making them adjustable. Serrations on the inner edge of both frame members provide an airtight filter lock.

"Alathon" makes possible other protective benefits. Non-toxic "Alathon" is unaffected by paint or perspiration and can be easily sterilized. It is tough—unbreakable in normal usage. Du Pont "Alathon" polyethylene resin can be injection molded, providing economy to the manufacturer. (Manufactured by Flexo Products, Inc., Cleveland 13, Ohio.)

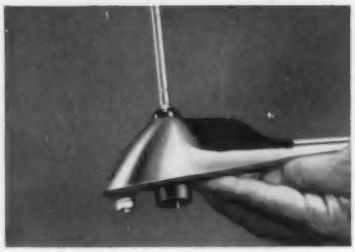
OVER

DU PONT
REG. U. S. PAT. OFF.

Better Things for Better Living ... through Chemistry

PRODUCT ENGINEERING NEWS

PROPERTY AND APPLICATION DATA ON THESE VERSATILE ENGINEERING MATERIALS: "ZYTEL," "ALATHON," "TEFLON," "LUCITE."

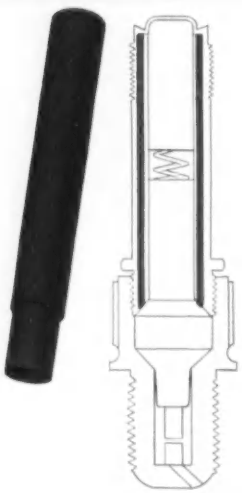


LUCITE® provides beauty and durability for antenna base

DU PONT "Lucite" acrylic resin adds a decorative touch to this auto radio antenna. "Lucite" was selected by Ford Motor Company for this job, because it is available in a wide range of attractive, non-fading colors and is unaffected by weather.

"Lucite" is shatterproof, light in weight, chemical resistant, and easy to keep clean. Because of this excellent balance of properties, Du Pont "Lucite" acrylic resin can solve a wide variety of product design problems involving long-term light transmission and outdoor weathering. "Lucite" is fabricated economically by injection and compression molding, extrusion and forming. For further information, use the coupon at the bottom of this page. (Molded by Sajar Plastics, Inc., Middlefield, Ohio. Manufactured by Tenna Manufacturing Company, Cleveland 25, Ohio.)

TEFLON® offers superior electrical and mechanical properties for aircraft spark plug insulators



Cutaway view of aircraft spark plug, showing two insulation sleeves of "Teflon" tetrafluoroethylene resin in red. (Spark plug manufactured by the Jet Ignition Company, Larchmont, New York. Sleeves of "Teflon" by Raybestos-Manhattan, Inc., Manheim, Pennsylvania.)

"Teflon" replaces ceramic . . . eliminates breakage problems

TWO THIN SLEEVES of "Teflon" tetrafluoroethylene resin outperform the ceramic insulator found in conventional aircraft spark plugs. The use of "Teflon" virtually eliminates the possibility of failure resulting from dropping, mishandling, normal engine vibration or other mechanical injury to the barrel of the plug.

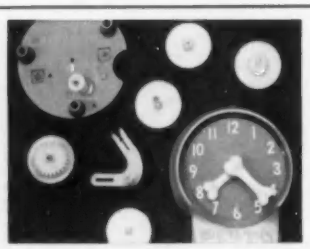
During the development and testing of the plugs, failure with standard ceramic sleeve insulators was experienced at 150 to 200 hours of operation. Failures were invariably due to the cracking of the ceramic insulator. No cracking has been observed with insulators of "Teflon", even after prolonged testing.

The insulating properties of "Teflon" are far superior to those of the ceramic sleeve. You will note from the illustration that two sleeves of "Teflon" are used—one inside the other. This provides added protection against dielectric failure.

Aircraft engine plugs with sleeve insulators of "Teflon", as illustrated, are approved by the CAA for use in the R-1820 engine and the Franklin 0-335-5 and 0-335-6 engines and are in use in these engines at the present time.

The mechanical, electrical, and chemical properties of "Teflon" have found use in a variety of design applications. Do you require material that is chemically inert? Suitable for use at extreme temperatures? Tough and resilient? For complete property data on this versatile Du Pont engineering material, mail the coupon at left.

Gear movement of "Zytel" nylon resin in Pluto novelty clock offers lightweight, compact design—plus smooth, quiet operation, with no lubrication. "Zytel" nylon resin is injection molded and requires no further finishing. Its strength and stiffness, even in thin sections, assure parts which will provide years of trouble-free service. (Clock by Allied Manufacturing Company, Seattle 44, Washington.)



E. I. DU PONT DE NEMOURS & CO. (Inc.) POLYCHEMICALS DEPARTMENT
Room 105, Du Pont Building, Wilmington 98, Delaware.
In Canada: Du Pont Company of Canada, Ltd., P. O. Box 660, Montreal, Quebec.

Please send me more information on the Du Pont engineering materials checked: ☐ *"Zytel";* ☐ *"Alathon";* ☐ *"Teflon";* ☐ *"Lucite". I am interested in evaluating these materials for:*

NAME_____ POSITION_____

COMPANY_____

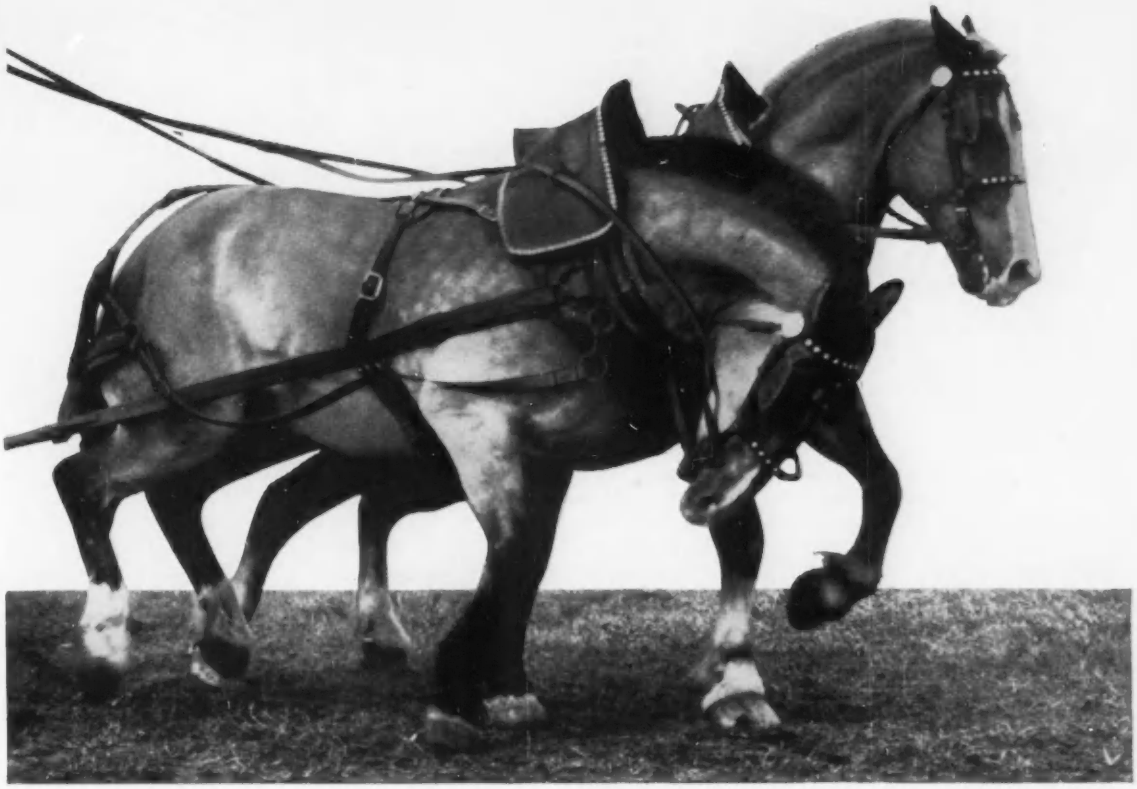
STREET_____

CITY_____ STATE_____

TYPE OF BUSINESS_____

NEED MORE INFORMATION?

For complete details that will help you further evaluate the Du Pont engineering materials for use in your product development programs, mail the coupon at the left. Specific property and application data will be sent to you.



Overloads Get You Nowhere... *FAST!*

Overloaded electric motors, too, soon get overheated and quit. Production stops. Money flies out the window.

But today manufacturers are preventing damage to motors from sudden overloads and frequent reversals, as well as from water, ozone, corrosive atmospheres, and hot locations, by using UNION CARBIDE Silicones in the insulation.

Not only does "Class H" insulation let a given motor operate safely under greater loads, but it also permits the use of a smaller motor to do equivalent work. The same applies to transformers and solenoids. A motor rewind job with UNION CARBIDE Silicones can make a motor last from ten to 100 times longer than before.

This is just one of the new, money-saving applications of UNION CARBIDE Silicones. They are proving their leadership as well for water repellents; intermediates; as release agents for rubber, plastics, shell molding; and for silicone rubber products of phenomenal heat- and cold-resistance.

These and other uses can be yours, along with the combined experience of UNION CARBIDE and its various Divisions that can be drawn upon to help you apply them correctly. Why not call in a UCC Silicone expert today!

"UNION CARBIDE" SILICONES TRADE-MARK formerly "LINDE" SILICONES TRADE MARK

SILICONES DIVISION

UNION CARBIDE
AND CARBON CORPORATION
30 EAST 42ND STREET UCC NEW YORK 17, N. Y.

In Canada: Linde Air Products Company, Division of Union Carbide Canada Limited
The term "Union Carbide" is a trade-mark of Union Carbide and Carbon Corporation

Silicones Division, Dept. P-5
UNION CARBIDE AND CARBON CORPORATION
30 East 42nd Street, New York 17, N. Y.

Please send me data on Silicones for:

☐ Class H Electrical Insulation ☐ Above-Grade Masonry Water Repellent
☐ Release Agents ☐ Rubber Gum Stock and Compounds

Name _____ *Title* _____
Company _____
Address _____
City _____ *Zone* _____ *State* _____

ALLIS-CHALMERS'

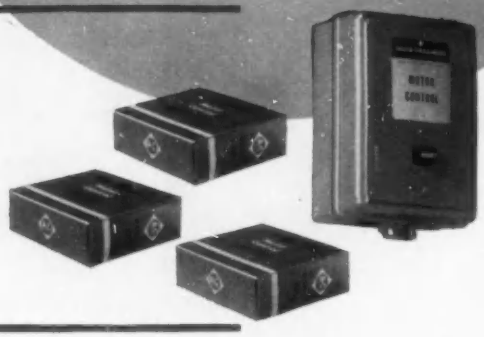
MOTOR CONTROL

a Complete Line

SIZE 0-3 STARTERS

Converta-Kits Permit Easy Modification of Basic Starter

You get MORE . . . more flexibility with Allis-Chalmers control. A screwdriver and the proper *Converta-Kit* are all you need to change a basic Allis-Chalmers size 0-3 starter into the exact unit demanded by your production. *Converta-Kits* are available for push-button, selector switch and electrical interlock modifications. Starter replacement parts—contacts, magnetic coils and overload relays —are also available in packaged kits.



1. Arc across contacts as they start to open.
2. Strong blowout action forces arc to center.
3. Contacts fully open — arc extinguished.

NEW LINE OF SIZE 4-5-6 STARTERS

Quick Quenching Extends Contact and Chute Life

Heart of these starters is a new contactor which uses a revolutionary principle of arc interruption. In centering the arc, increased blowout action and fast quenching result from a combination of thermal convection and magnetic action. Since the arcing time is sharply curtailed, contact and chute life are greatly extended.

HIGH VOLTAGE STARTERS

Complete "Line-to-Load" Control and Protection

Allis-Chalmers Type H starters are built in a wide range of ratings for squirrel-cage, wound-rotor and synchronous motors . . . for full or reduced voltage — reversing or non-reversing — with plugging, dynamic braking and multi-speed features. Built into the starter is the type and degree of protection dictated by the application.

What is your control problem?

As manufacturers of a diversified line of industrial equipment, Allis-Chalmers has solved thousands of control application problems. This specialized experience is yours when you specify Allis-Chalmers control. See your Allis-Chalmers representative or write Allis-Chalmers, General Products Division, Milwaukee 1, Wisconsin.

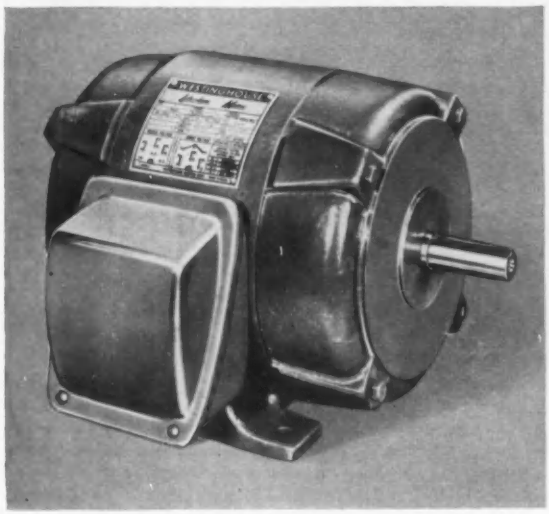
Converta-Kit is an Allis-Chalmers trademark.

A-C ALLIS-CHALMERS

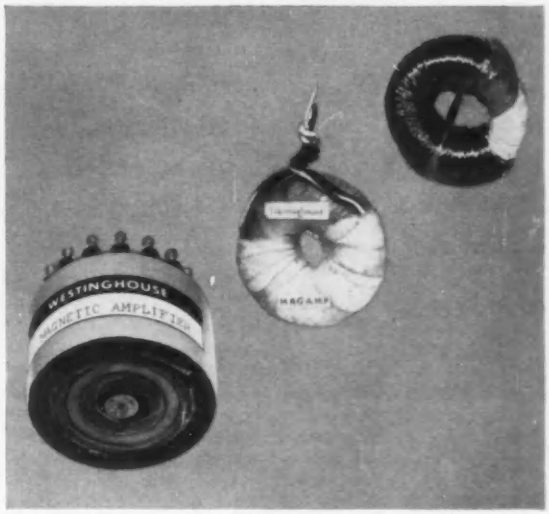
A-4988

ALLIS-CHALMERS

HERE'S WHY DU PONT MYLAR® IS GOOD NEWS AT WESTINGHOUSE!



SMALLER, MORE DURABLE MOTORS. "Slot liners and phase separators made with 'Mylar' are thinner yet stronger . . . contribute to motor-size reductions," reports Westinghouse. "'Mylar' makes possible insulation with 7 times the physical strength and no reduction in dielectric strength when compared with conventional insulation—helps us obtain smaller, lighter motors that last up to 50% longer."



ELIMINATES REJECT PROBLEM. "When testing our 'Magamp' magnetic amplifiers under humid conditions, a high reject rate occurred. But when we started using 'Mylar' as the insulating material," Westinghouse engineers report, "the reject problem was completely eliminated. That's because 'Mylar' combines moisture insensitivity with high dielectric strength."

Can "MYLAR" help you develop new products . . . improve established ones?

These successful Westinghouse applications of "Mylar"* are only two examples of the way industry is taking advantage of the unique balance of properties in this tough, flexible, transparent film. Besides its contribution to the electrical-electronics field, Du Pont "Mylar" is making possible better products for manufacturers in the automotive, construction, chemical, textile, sound recording, printing, and other major industries.

Whether you make guided missiles or ladies' handbags, "Mylar" may be able to help improve performance . . . increase the over-all value of your product. For more information on properties, applications and types of "Mylar" available, send in the coupon below. Be sure to specify the application you have in mind.

DU PONT
REG. U.S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

**"Mylar" is Du Pont's registered trademark for its brand of polyester film.*

In Canada, "Mylar" is sold by Du Pont Company of Canada Limited, Films Division, P. O. Box 660, Montreal, Quebec.

DU PONT
MYLAR®
POLYESTER FILM

E. I. du Pont de Nemours & Co. (Inc.)
Film Dept., Room P-5, Nemours Bldg., Wilmington 98, Del.

Please send your booklet (MB-4) on properties, applications, and types of "Mylar" polyester film available.

Application_____

Name_____

Firm_____

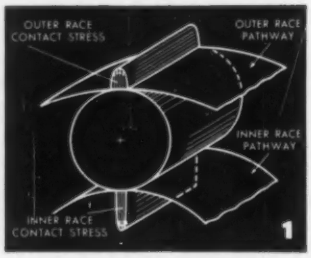
Address_____ City_____ State_____

ONE OF A SERIES OF INFORMATIVE MESSAGES FROM HYATT...

Cylindrical Roller Bearing Outer Races

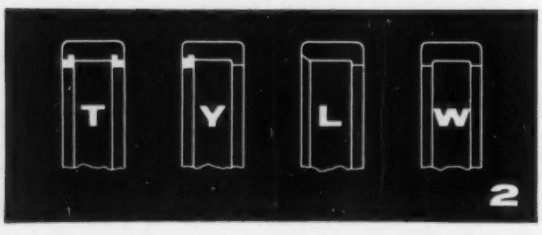
Why they are necessary . . . their importance in relation to bearing versatility . . . wide variety of configurations and locating devices

Outer races are necessary parts of all roller bearings, except in cases where a roller operating surface of suitable hardness and finish can be provided in the housing. In housings of aluminum, cast iron or unheat-treated steel where a hardened and ground surface cannot be obtained by any practical means, outer races are required to assure a fatigue-resistant pathway on which the rollers can operate smoothly.



The outer race is not normally the critical member of a cylindrical roller bearing. This does not mean, however, that outer races cannot suffer fatigue failure. All objects subjected to stress repetitions can fail after a small number of stresses—or may enjoy a surprisingly long life. But experience definitely shows that percentages favor the outer race, and the reason is apparent in Figure 1, which shows a roller engaging both an outer and inner race. Note that the load is spread over a larger area of contact on the outer race, which results in a much smaller maximum stress. This demonstrates in part the principal reason why inner races are the critical member of most cylindrical roller bearings, as explained in one of our previous messages.

Nevertheless, HYATT outer races are manufactured with the same scrupulous care that is applied to inner races and all other components of HYATT Bearings. Outer race performance must match the performance of the rest of the bearing. We consider the fact that the outer race is not the critical member as a safety factor—*not a license to reduce quality.*



1. OUTER RACE TYPES

HYATT Hy-Load outer races are available in a variety of standard configurations for every type of application requirement (Figure 2). The W, L and Y races have solid flanges capable of sustaining light or intermittent thrust loads. The T and Y races are assembled with internal snap rings; they have equal radial load-carrying capacity but are not recommended for applications where a continuous thrust would be taken by the snap rings. The T, Y, L and W races may all be mounted using the roller ends against either the solid shoulder or internal snap ring for purposes of locating the outer race axially.

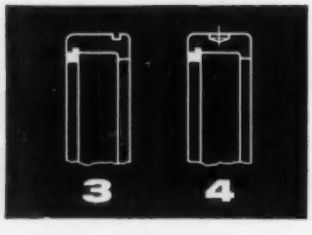
2. CIRCUMFERENTIAL LOCATION

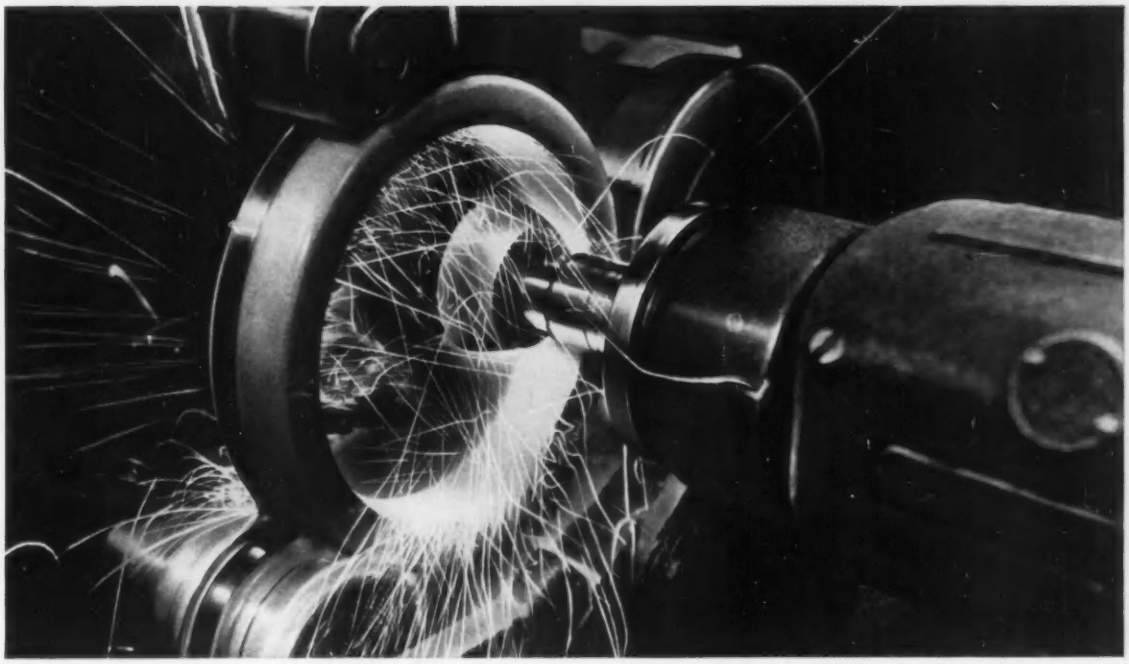
An ample choice of outer race locating methods may be used with HYATT Hy-Loads. Circumferential location is often accomplished by the use of a press fit. (Our general recommendation is that the *rotating* race be applied with a press fit and the *stationary* race be applied with a push fit.) When a push fit is employed, circumferential location is satisfactorily accomplished by axial clamping against the race ends. *Positive* circumferential location is provided by the use of an outer race dowel.

3. AXIAL LOCATION

Axial location of an outer race is conventionally accomplished by pressing or pushing the race to a housing shoulder. The race may be constrained from "walking out" of the housing bore by the flange or snap ring operating against the roller ends. *Positive* axial location is accomplished by axial clamping against a housing shoulder or snap ring.

It may occur, however, that a shoulder is not available in the housing. Under these circumstances, it is necessary to employ an auxiliary holding device such as an external snap ring or an outer race dowel. HYATT Hy-Load Bearings can be supplied to original equipment builders with outer races having a snap ring groove (Figure 3) or a blind dowel hole (Figure 4) at small added cost.





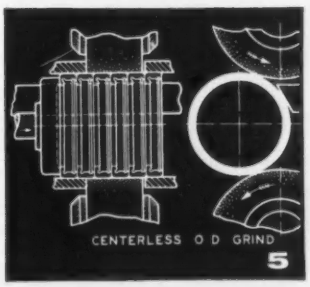
Grinding the flange on a Hyatt outer race.

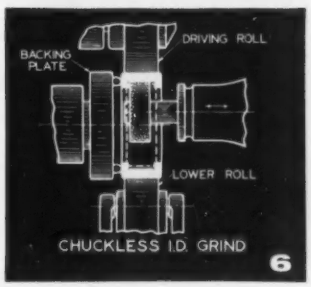
4. OPERATIONAL REQUIREMENTS

Since the outer race is usually the stationary member of the bearing, the exact maintenance of wall variations and runout is not ordinarily critical. However, the outer race *may* be the rotating race in certain applications—so quality controls are rigidly applied to all HYATT outer races to maintain:

a. Minimum wall variation. **b.** Minimum runout of race ends to bore. **c.** Minimum runout of race flange inner faces to bore. **d.** Minimum pathway and outer diameter taper. **e.** Minimum outer diameter tolerance.

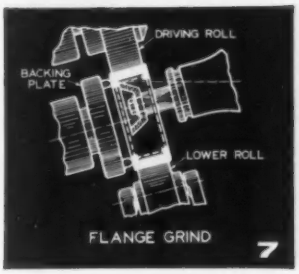
5. MANUFACTURING PROCEDURES





During manufacture, the following sequence of operations provide the controls necessary to generate outer races which meet the strict operational standards maintained by HYATT: After careful primary machining and heat treating, the ends are faced off square and parallel by a double end grind. This provides a reference surface from which all runouts and squareness can be gaged. Outer race diameters are generated by the centerless grinding method to provide an O.D. with as little out-of-round as practical. The through-feed method of grinding represents a valuable economy (Figure 5) to help reduce race costs.

Next, the pathway (or race I.D.) is ground centerless, generating a cylinder concentric with the O.D. cylinder. This is accomplished by driving the race on the O.D. and positioning the grinding wheel relative to the drive roll (Figure 6). Finally, the flanges are ground using the race ends as a reference. The result is a race of as nearly perfect geometry as is practical (Figure 7). It is then critically inspected to insure traditional HYATT dependability and the maximum possible service life.



YOU WILL FIND FURTHER DETAILS in HYATT General Catalog No. 150, or your nearby HYATT Sales Engineer will gladly help you choose the type of cylindrical roller bearings best suited to your design requirements. Remember, HYATT is America's *first* and *foremost* maker of roller bearings. Hyatt Bearings Division of General Motors, Harrison, N. J.

GM GENERAL MOTORS

HYATT ROLLER BEARINGS

efficient, long-wearing seals produced at reasonable cost with compatible

GRAPHITAR® *and*

GRAMIX® PARTS

GRAPHITAR is not only a high-quality seal material, but when produced in volume, an economical one as well. In low-pressure applications where mechanical seals have heretofore been too expensive, the Gits Bros. SGU stock shaft seal, using GRAPHITAR wearing and sealing elements, is finding wide use. Cost of the GRAPHITAR seal rings is reasonable enough to make the SGU practical in such high-volume products as washing machines, garbage disposal units, and pumps. Performance is excellent, due to GRAPHITAR'S low friction, high strength, durability, self-lubricating properties and its guaranteed continuing inertness to all known detergents. The long life of the SGU seal is further assured with a GRAMIX Grade 263 nickel-bronze seal-seat. GRAMIX Grade 263 is also corrosion resistant to detergents and the wear and sealing-in characteristics are especially compatible with those of GRAPHITAR. As a result, the Gits SGU shaft seal combines economy with very efficient operation, and is manufactured in standard sizes ¼″ thru 2″ and in shaft increments of ⅛″.

SGU Seal Performance Data:

Speeds.....1750 to 3600 FPM	*Sealed Liquids* Soaps, Greases, Animal Fats, Strong Detergents
Temperatures Continuous.....250°F. Intermittent.....275°F.	*Lubrication* Soaps, Greases, Animal Fats, Strong Detergents and water splash lubrication
Pressures Normal.....10 to 15 psi Maximum.....35 to 40 psi	

THE UNITED STATES

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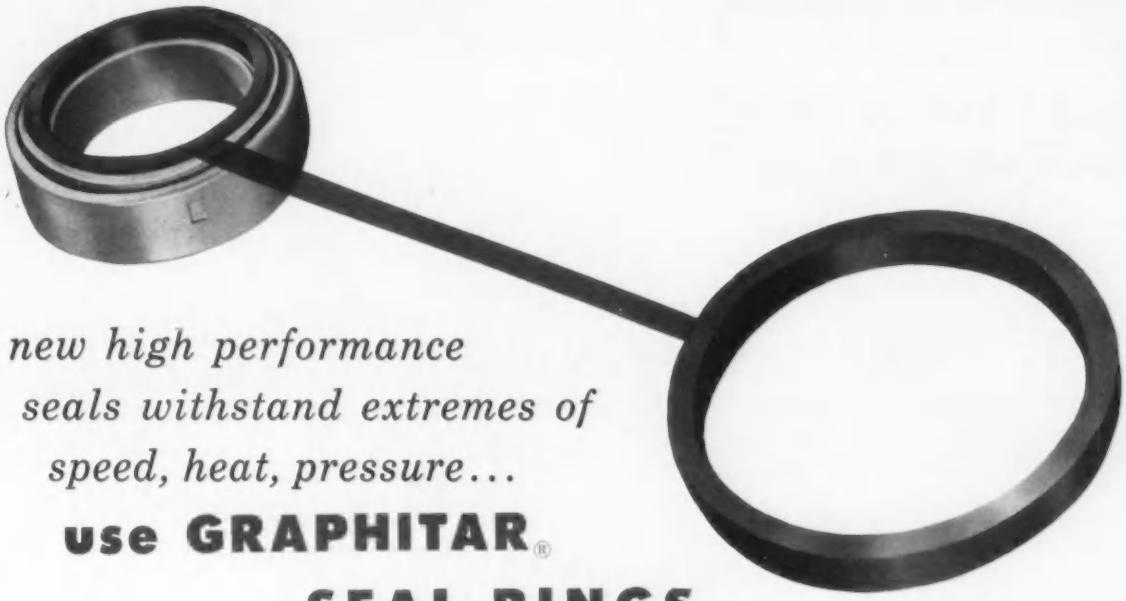


new high performance seals withstand extremes of speed, heat, pressure...

use GRAPHITAR® SEAL RINGS

The Gits Bros. style HH stock shaft seal has been designed for use in aircraft accessories and in other equipment where maximum performance is demanded. This seal meets minimal space requirements, and, due to its GRAPHITAR seal ring, can perform under extremes of temperature, pressure, and seal face surface speed. GRAPHITAR, being an inert carbon-graphite material, is relatively unaffected by such extreme operating conditions, and is likewise unaffected by most chemicals or acids . . . even very corrosive ones. GRAPHITAR possesses excellent sealing qualities, a low coefficient of friction, a long wear life, and is in addition self-lubricating. These properties assure the HH seal of efficient operation with a minimum of maintenance . . . very important in such end uses as jet aircraft, reciprocating accessory units, and hydraulic pumps. Gits Bros. manufacture these seals in *standard sizes* ¼" thru 4" and in shaft increments of ⅛".

HH SEAL Performance Data:

Speeds.....20,000 feet per min.	*Sealed Liquids*
Temperatures.....400°F. maximum	Aircraft fuels and oils
Pressures.....1000 psi maximum	*Lubrication*
	Mists, vapors, full fluid

VERSATILE GRAPHITAR seals, bearing, vanes, piston liners, and many other parts show improved characteristics. GRAPHITAR parts are made from carbongraphite powders compacted in dies under great pressure and furnaced at temperatures near 4500°F. They can be relatively complicated in shape, and are ground to tolerances as close as .0005". GRAPHITAR is lightweight, strong, and durable, chemically inert, and virtually unaffected by extremes of speed, pressure, or temperature. It can be operated dry, or where water, steam or another fluid are the only lubricants. Write today for our illustrated 64-page GRAPHITAR catalog.

GRAPHITE COMPANY

DIVISION OF THE WICKES CORPORATION, SAGINAW, MICHIGAN

NOW AVAILABLE!

Carpenter PVC pipe and fittings for cost-saving corrosion control

● Here is a new Carpenter service to help processing plants cut piping costs for handling a wide variety of corrosives under moderate operating temperature and pressure conditions. Carpenter PVC Plastic Pipe and Fittings are admirably suited for such piping requirements because of the excellent corrosion resistance, strength and other desirable properties of the unplasticized polyvinyl chloride from which they are made. They withstand both oxidizing and reducing conditions. For this reason, Carpenter PVC Pipe and Fittings supplement other corrosion-resistant piping materials previously made available by Carpenter research and production advances in stainless and specialty steels.

Two types of Carpenter PVC Pipe and Fittings are available—No. 1 provides outstanding chemical resistance along with high strength, toughness and rigidity. No. 2 provides high impact strength and excellent corrosion resistance. Both types are available in eight pipe sizes of ½″ to 4″. Pipe is made in Schedules 40 and 80. A full line of Schedule 80 threaded and socket fittings is available.

Easily and economically installed with usual piping tools, Carpenter PVC Pipe and Fittings assure trouble-free service with cost economy. Why not look into the advantages of using Carpenter PVC piping systems in your plant? Consult your nearby Carpenter Distributor or Representative and ask for new Technical Bulletin T.D. 119.

MEMBER

The Carpenter Steel Company, Alloy Tube Division, Union, N. J.

Export Dept.: The Carpenter Steel Co., Port Washington, N.Y.—"CARSTEELCO"

Carpenter

PVC Pipe and Fittings

Miller

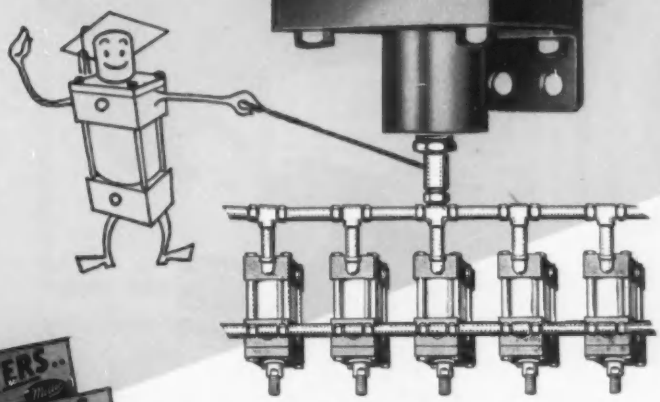
FLUID PRESSURE BOOSTERS

BOOST 80 PSI AIR

Input Range: 40 to 3000 psi Air or Fluid

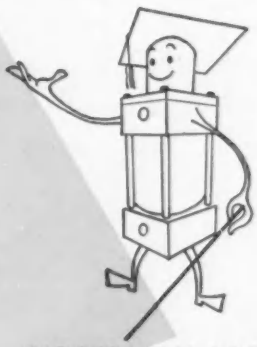
TO 2000 PSI HYDRAULIC PRESSURE

Output Range: 200 to 10,000 psi Fluid



- Save space, weight and investment cost by replacing pump installations in many applications.
- Less costly to install, operate and maintain.
- **Hold Pressure indefinitely** without the motion and heat generation of ordinary pump circuits
- Provide—at point of cylinder thrust—more efficient power with less weight in less space than direct driven air cylinders
- Save up to 95% of air consumed by direct driven air cylinders
- Operate at speeds of 30 to 450 strokes per minute

NOTE: In addition to its most complete line of "Custom-Built" Boosters available on normal delivery Miller offers 5" bore, 25 to 1 ratio, boosters for immediate delivery in either 6" or 12" stroke. Write for data and prices.



ESPECIALLY RECOMMENDED FOR

- **WELDING**
- **PUNCHING**
- **SHEARING**
- **CLAMPING**
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- **CRIMPING**
- **PRESSING**

and similar applications

FULL DETAILS IN MILLER BULLETIN B-200 SENT FREE ON REQUEST

Other Miller products include: Air cylinders, 1½" to 20" Bores, 200 PSI operation; low pressure hydraulic cylinders, 1½" to 6" bores for 500 PSI operation, 8" to 14" bores for 250 PSI; high pressure hydraulic cylinders, 1½" to 12" bores, 2000-3000 PSI operation. All mounting styles available.

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Miller

MILLER FLUID POWER DIVISION FLICK-REEDY CORP.

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AIR & HYDRAULIC CYLINDERS • BOOSTERS • ACCUMULATORS
COUNTERBALANCE CYLINDERS

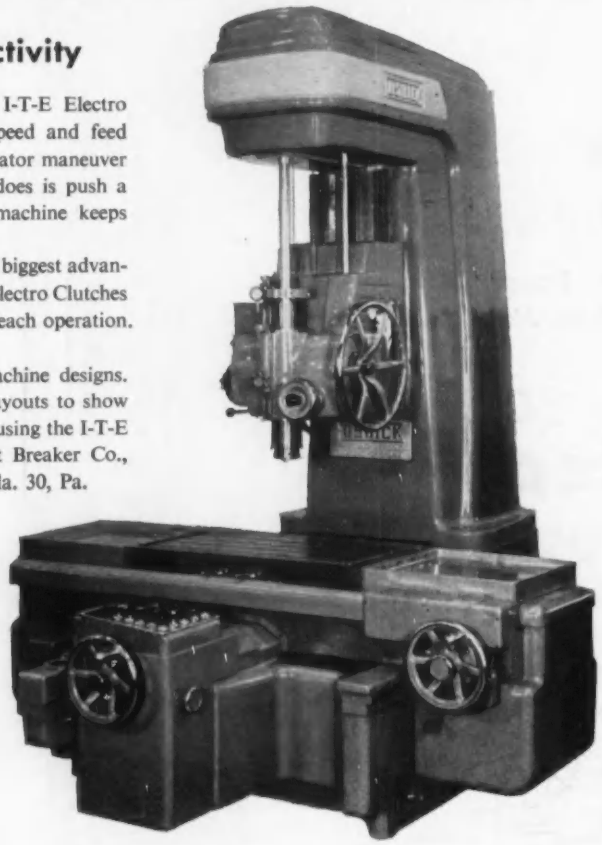
I-T-E ELECTRO CLUTCHES MAKE POSSIBLE SPEED AND FEED CHANGES IN 1/2 SECOND

Easier operation boosts productivity

The Fosdick Machine Tool Co. has now incorporated I-T-E Electro Clutches into its precision jig borers. Formerly every speed and feed change meant the machine had to be stopped and the operator maneuver a mechanical slide-gear shifting mechanism. Now all he does is push a button on the conveniently located control panel. The machine keeps running; keeps producing.

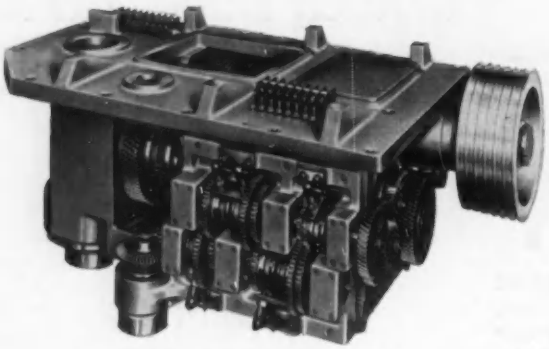
Easier operation and increased production—these are the biggest advantages that I-T-E Electro Clutches can add to machine tools. Electro Clutches make it easier to operate machines at their best speeds for each operation. In addition, they have transmission gear space.

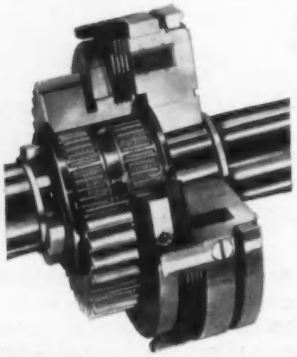
I-T-E Electro Clutches are available to fit existing machine designs. I-T-E application engineers will be glad to help prepare layouts to show you the space-saving possibilities and ease of control when using the I-T-E Electro Clutches. Write for Bulletin #5306. I-T-E Circuit Breaker Co., Transformer-Rectifier Division, 19th & Hamilton Sts., Phila. 30, Pa.



FOSDICK PRECISION JIG BORER MODEL H-1015

SPACE SAVER. Complete transmission for the Fosdick machine. Notice compactness and simplicity for mounting I-T-E Electro Clutches on same shafts with gears. Clutches operate right in housing with oil lubricant.



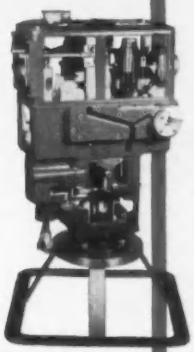


NO ADJUSTMENTS. The I-T-E Electro Clutch is simple, compact, requires no adjustments for wear. Available in torque ratings from 3.2 ft. lb. to 45,000 ft. lb.

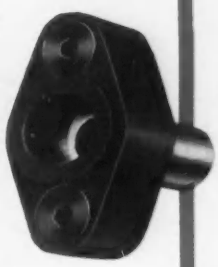
I-T-E CIRCUIT BREAKER COMPANY • Transformer-Rectifier Division

5 practical ways to "streamline"

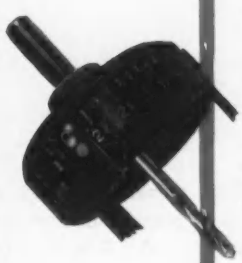
...without sacrificing fastening strength



1. Counterbored holes are the simplest approach to flush surfaces using standard socket cap screws. The advantage of specifying genuine Allen ○ Head Cap Screws is the greater strength of Allenoy steel... you can use smaller sizes for closer spacing and reduced weight. Call on Allen, too, for *very large* socket-head, precision cap screws — up to 2½ inch diameter.



2. Countersinking enables you to get absolutely smooth external surfaces using Allen ○ Flat Head Cap Screws. Allen ○ Cap Screws feature the exclusive Leader Point which makes screw starting easier and guards against thread damage.



3. Button Head Cap Screws produce snag-free unbroken surfaces where countersinking is impractical. Button-head hex sockets are necessarily shallow. In genuine Allen ○ Button-Head Cap Screws, sockets are cold forged without broaching, in extra strength Allenoy steel... essential protection against stripping the sockets under high torque pressure.

4. A ready made hole tapped in forged steel solves many a design problem. It's called the Allenut. It can be anchored in soft material to assure durable threading, or recessed to permit tightening with an Allen Hex Key.

5. Bright finish, or rust and corrosion resistance call for Allen ○ Stainless Steel Cap Screws. They are standard stocked items (both NF & NC threads) readily available in a wide range of sizes from Allen Distributors.

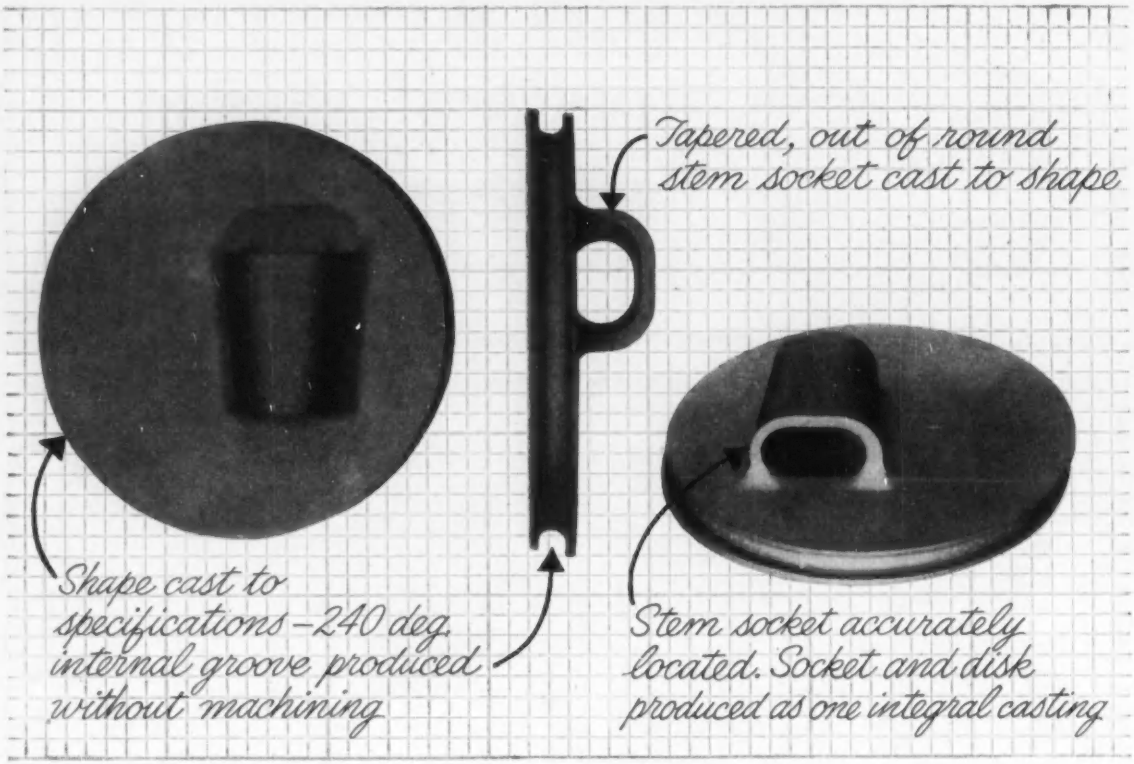
YOUR ALLEN DISTRIBUTOR can give you practical help and swift service. For complete information on any technical fastening problem, write our engineering department direct.

ALLEN HEAD

ALLEN

MANUFACTURING COMPANY

Hartford 2, Connecticut, U.S.A.


Tapered, out of round stem socket cast to shape
Shape cast to specifications – 240 deg. internal groove produced without machining
Stem socket accurately located. Socket and disk produced as one integral casting

Investment-Cast in One Piece . . . 5 Secondary Operations Avoided

This intricate valve disk and stem socket were investment cast at a considerable saving in machining, assembling, and joining costs. The disk is produced in an odd shape and has a concave rim with a 240-degree groove. There is a tapered, out-of-round recess in the stem socket. The disk and socket were designed and produced as one integral casting.

The shape of the disk, vital to the proper functioning of the part, was cast to size. A contour machining operation would have been required to produce this shape by other methods. The groove in the rim of the disk, and the stem socket, were also cast to size . . . thus eliminating two more difficult machining operations.

An assembly operation, which would have required precision locating devices, was also avoided. The stem socket had to be accurately located . . . 0.225 in. from the centerline of the disk. This location was held to within plus or minus 0.005 in. on the finished part by the investment-casting method.

Reducing production costs by eliminating secondary operations is only one of the many advantages of HAYNES' precision-investment-casting process. For the full story call or write to any of the District Sales Offices listed below:

HAYNES TRADE-MARK ALLOYS

HAYNES STELLITE COMPANY

A Division of Union Carbide and Carbon Corporation

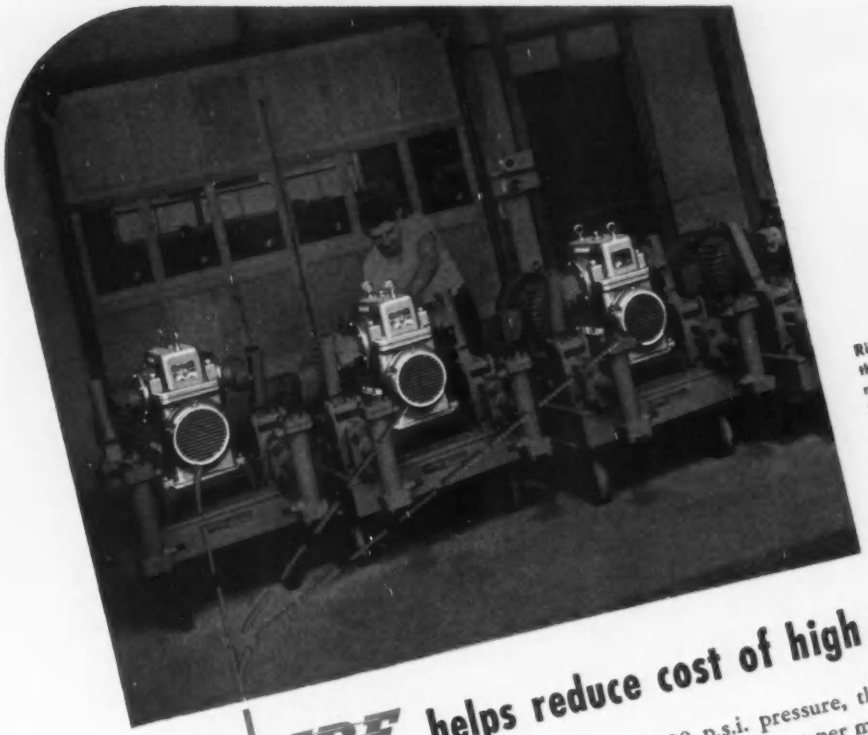
UCC

General Offices and Works, Kokomo, Indiana

Sales Offices

Chicago • Cleveland • Detroit • Houston • Los Angeles • New York • San Francisco • Tulsa

"Haynes" is a registered trade-mark of Union Carbide and Carbon Corporation



Right off the assembly line, these Philadelphia Pumps are ready for action. Driven by Speedaire . . . these rugged, heavy-duty pumps are assured of a sturdy power source.

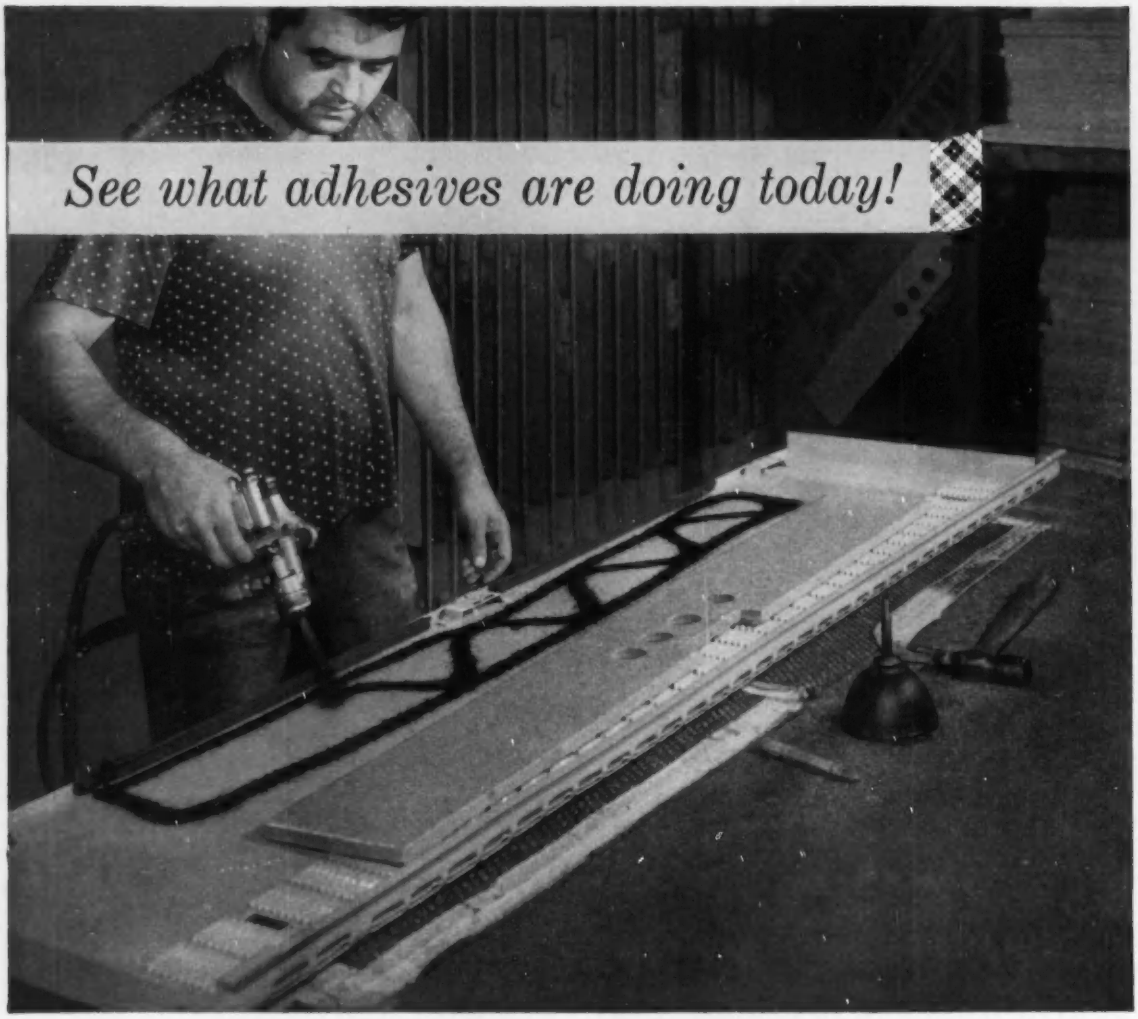
SPEEDAIRE helps reduce cost of high pressure pump

DESIGNED to operate at 3,000 p.s.i. pressure, this 50% metal slurry pump delivers 3 gallons per minute. Built to handle tough, unusual jobs, it is driven by a tough, unusual speed reducer—the Cleveland Speedaire. Not only did Speedaire offer the smaller frame size needed for this unit, it also helped substantially to reduce its price. Speedaire costs hundreds of dollars less than a conventional drive of comparable capacity.

Further, the fan-cooled Speedaire worm gear reducer runs cool and smoothly under a heavy load, unaffected by heat, moisture and grime. Thousands are in service. Chances are you can use one or more right now! If you aren't familiar with Speedaire, just call us. Ask for a copy of Catalog 400. The Cleveland Worm and Gear Co., 3279 East 80th St., Cleveland 4, Ohio.

Affiliate: The Farval Corporation, Centralized Systems of Lubrication. In Canada: Peacock Brothers Limited.

CLEVELAND
Worm Gear
Speed Reducers



Harnessing heat for safety's sake

3M ADHESIVES

A temperature of 215° F. is just too hot to handle, no matter where you find it. Yet today's wall-type room heater must operate at just such a temperature *inside*, while staying cool enough on the *outside* so that even a child can touch it in perfect safety. What's behind this bit of modern insulation magic? A 3M product called EC-321—the versatile adhesive you see in action above.

Applied quickly and easily by spray, EC-321 has "quick strength" . . . takes a gentle grip on the insulation immediately upon contact, simplifying the manufacturer's assembly operation. Then the adhesive dries to form a lasting bond that *keeps* the insulation at its cooling job—without a slip—despite the boiling-hot temperatures generated inside the heater.

See what adhesives can do for you . . .

Call upon 3M research for the solution to your specific design or production problem. Call an expert, your nearest 3M Field Engineer—or write for further information to 3M, Dept. 45, 417 Piquette, Detroit 2, Mich.

ADHESIVES AND COATINGS DIVISION **MINNESOTA MINING AND MANUFACTURING COMPANY**

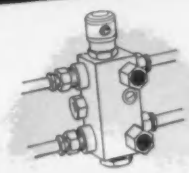
417 PIQUETTE AVE., DETROIT 2, MICH. • GENERAL SALES OFFICES: ST. PAUL 6, MINN. • EXPORT: 99 PARK AVE., N.Y. 16, N.Y. • CANADA: P.O. BOX 757, LONDON, ONT.

MAKERS OF "SCOTCH" BRAND PRESSURE-SENSITIVE ADHESIVE TAPES • "SCOTCH" BRAND SOUND-RECORDING TAPE • "SCOTCHLITE" BRAND REFLECTIVE SHEETINGS • "3M" ABRASIVE PAPER AND CLOTH • "3M" ADHESIVES AND COATINGS • "3M" ROOFING GRANULES • "3M" CHEMICALS

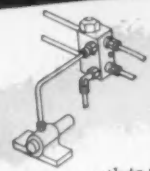
Meets **toughest** lubrication requirements!

Can be designed into any machine, in **4 easy steps**

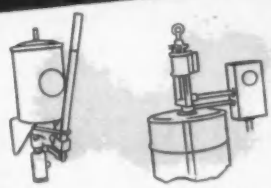
1. Remove grease cups or grease fittings.



2. Connect each valve in system to its two lubricant supply lines.



3. Connect valve outlets to inlet of bearings. (Each valve serves two bearings.)

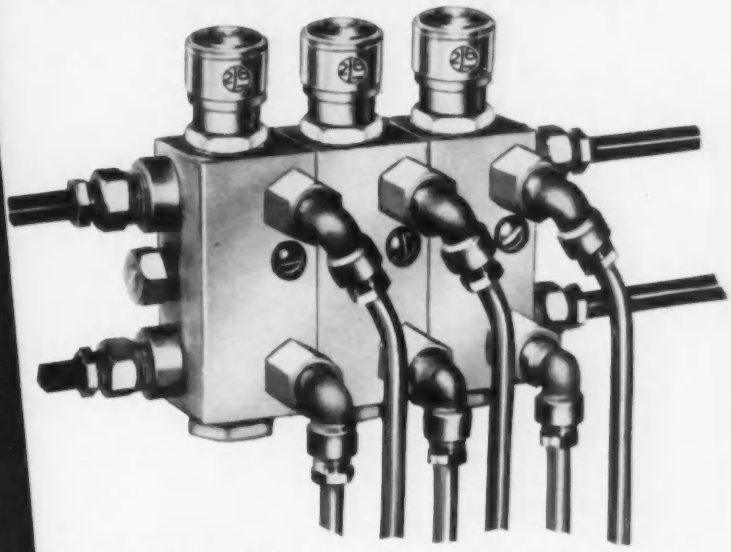


4. Provide central pump for supplying lubricant to system.

ALEMITE

Accumatic®

CENTRALIZED AUTOMATIC LUBRICATION



Alemite Type II Accumatic Valves meet big-volume requirements . . . handle difficult multiple-bearing lubrication under all conditions. Fully sealed for *clean* lubrication of power shovels, cement kilns, conveyors – any outdoor or indoor installation. Operate whether completely immersed in fluid . . . covered by dirt or grit . . . or protected by anti-corrosive paint. For fluid oil or light grease. Four sizes, delivering from .050 to .500 cu. in. of lubricant. Fully hydraulic – no springs to adjust or replace.

Now available with Lubrication Recording Cycle Counter – for a fully automatic record of bearing lubrication!

FACTORY-TESTED – FIELD-PROVED!

Tests show no appreciable variation in the amount of lubricant discharged after 73,312 cycles – equal to *122 years of twice-a-day service!*

ALEMITE

REG. U. S. PAT. OFF.

A Product of STEWART-WARNER CORPORATION

Alemite Accumatic Type II Offers All These Advantages!

- Prevents application of wrong lubricant.
- Seals completely against dirt, grit, water.
- No parts are neglected – lubricates inaccessible and dangerous bearings.
- Eliminates product spoilage due to over-lubrication.
- Eliminates point-by-point lubrication methods – services all bearings in one operation.
- Delivers exact amount of lubricant to bearing.

FREE!

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1850 Diversey Parkway, Chicago 14, Illinois

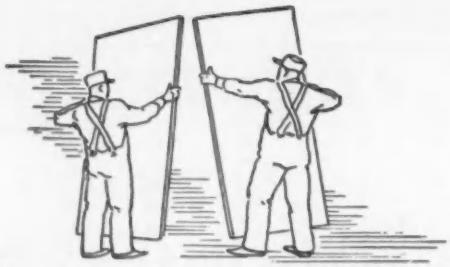
A PRODUCT OF SW STEWART WARNER

Please send me my free copy of the Alemite Accumatic Catalog.

Name .....

Company .....

City ..... State .....



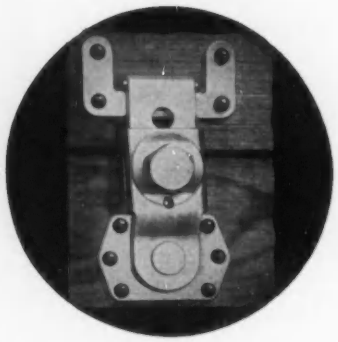
Have you a similar fastening problem?

How a strong structure can be designed for speedy and simple assembly with unskilled labor, no special tools...

The U. S. Air Force wanted a jet-aircraft hangar design that would be portable by air, yet strong; would assemble quickly; be interchangeable, and flexible enough for easy structure modification.

The answer lay in a panel structure using modular units. Armorply honeycomb panels faced with thin aluminum, developed by United States Plywood Corporation, provide lightness, strength, flexibility. Joining one panel to the other in the field with untrained help was a problem until Simmons Fastener developed LINK-LOCK, a simple latching device that operates with minimum wrench pressure on hex nut.

This fastening problem is being successfully met by combining the design ingenuity of No. 1 LINK-LOCK with the proved performance of honeycomb plywood panels.



No. 1 LINK-LOCK—like No. 2 LINK-LOCK—features simplicity, positive action, high strength.

No springs are used in No. 1 LINK-LOCK. Locking action is obtained by rotating a nut that moves a sliding latch in and out of position. Up to 1500-lb. pull-down pressure is available; the device carries up to 4000-lb. tension. No. 1 LINK-LOCKS provide for surface mounting, simplifying installation.

Where can you use it? When you need heavy fastening pressures, resistance to impact, operation in 70-below temperatures—and where ease of action, compactness, and low cost are important factors. Write for a No. 1 LINK-LOCK Data Sheet.

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1751 North Broadway, Albany 1, New York

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DESIGN ENGINEERING SHOW
Convention Hall, Philadelphia, May 14-17

Simmons

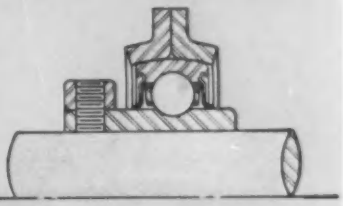
QUICK-LOCK SPRING-LOCK ROTO-LOCK LINK-LOCK DUAL-LOCK

JUST OUT! NEW 36-PAGE CATALOG WITH APPLICATIONS. SEND FOR IT!

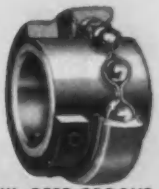
MORE FACTS on why more and more leading manufacturers choose Link-Belt bearings

THIS NEW HOLLAND HAY BALER is typical of equipment on which JPS-200 ball bearing pillow blocks are popularly applied.

SELF-ALIGNING. Free-rolling and full load capacity of the JPS-200 ball bearing pillow block are maintained even with shaft deflection or misalignment.



MAXIMUM SEALING EFFICIENCY. Synthetic rubber lip-type seal, integral with bearing, keeps lubricant in, dirt out. Greased at factory ready for operation.



SINGLE-ROW, DEEP-GROOVE standard Series 200 ball bearing is used. Extra-long inner ring assures proper load distribution—heavy spring locking collar firmly secures bearing on shaft.

√Low cost √Compactness √Self-alignment

Link-Belt JPS-200 ball bearings combine all three

HERE is a new concept in bearing design—a proven answer to the economy needs of many equipment manufacturers. And most important—this JPS-200 Series ball bearing pillow block achieves low cost without sacrifices in bearing design.

The standard, full-capacity, self-aligning Series 200 ball bearing is supported in a rugged, pressed steel housing. Further economies result because the JPS-200 arrives in *one piece*—ready for fast, foolproof installation. And standard dimensions plus extreme compactness are added aids to the designer.

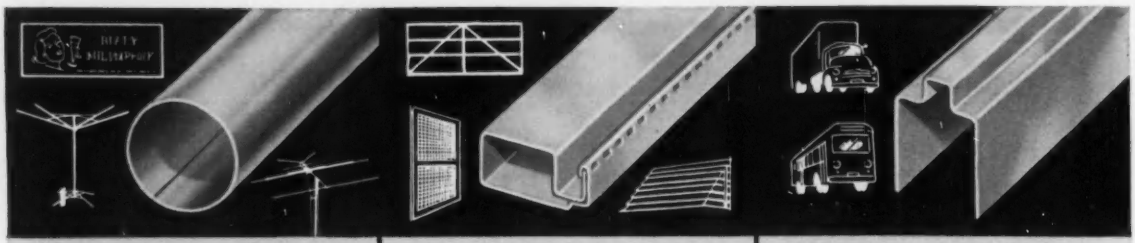
Ask any one of 40 Link-Belt offices for Folder 2517 containing complete information on the JPS Series. And get Book 2550 for data on Link-Belt's complete ball and roller bearing line.

LINK-BELT

Ball and Roller Bearings

Rugged, steel-clad JPS-200 Series — from industry's most complete line of ball and roller bearing pillow blocks.

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office: New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World. 13.389-A



High strength and superior finish of aluminum roll formed tubing pays off in sign frames of all sizes, TV antenna, clothes dryers and many other products.

Parts for window screens, farm gates, car ports, awnings and other building products are economically produced with aluminum roll formed shapes.

Many complex truck and trailer framing members, bus strips and other parts are easily fabricated with aluminum roll formed shapes.

Specify ALUMINUM Roll Formed Shapes from REYNOLDS

for economy, design freedom, dimensional accuracy and better finishes

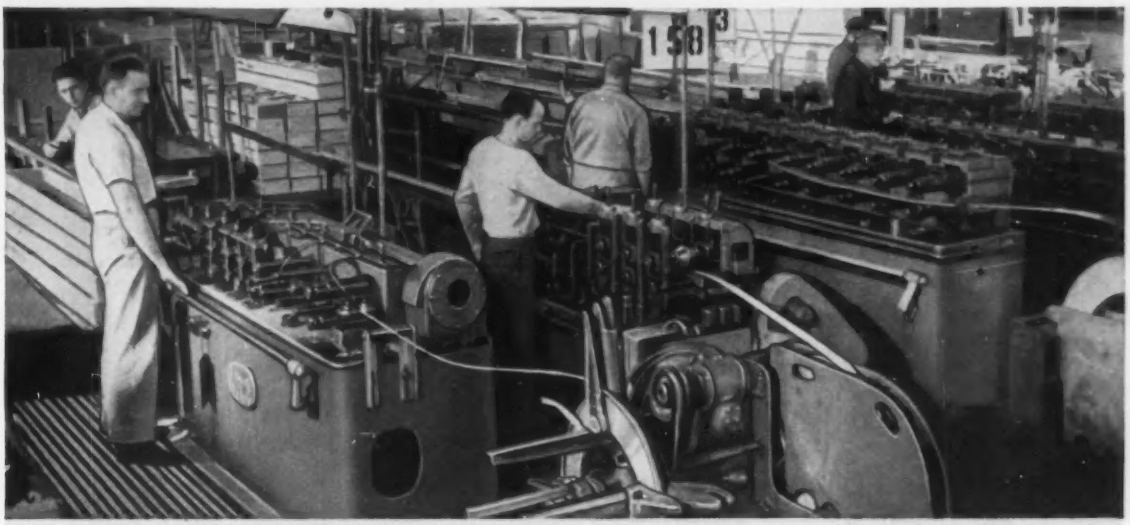
Rolling from coil stock permits savings that are impossible when working from flat sheet. Therefore, if you are fabricating a complex shape from flat sheet, or if you require a shape in long lengths, it will pay to switch to aluminum roll formed shapes from Reynolds.

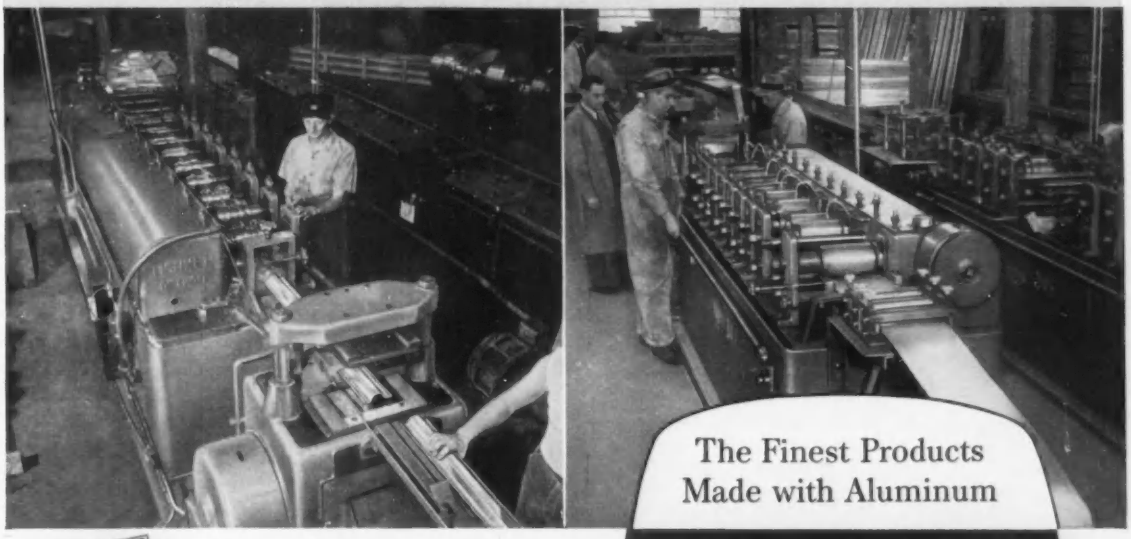
Reynolds roll forming can produce a wide range of easily fabricated shapes that aid in design flexibility. Closer tolerances on Reynolds roll formed shapes mean dimensional accuracy; better as-fabricated finishes often mean a more attractive product without additional finishing operations.

However, if an unusually high quality finish is important to the sales appeal of your aluminum product, Reynolds is your best source for clear anodized, color anodized or chemically brightened finishes on roll formed shapes. Reynolds new expanded finishing facilities go hand in hand with Reynolds sizable investment in roll forming machines and tooling.

For details contact your nearest Reynolds Office listed under "Aluminum" in your classified telephone directory or write *Reynolds Aluminum Fabricating Service, 2051 South Ninth Street, Louisville 1, Ky.*

REYNOLDS ALUMINUM FABRICATING SERVICE





The Finest Products
Made with Aluminum

are made with

REYNOLDS ALUMINUM

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Write for your free copy of 8-page brochure, "Aluminum Roll Formed Shapes by Reynolds".

See "FRONTIER", Reynolds exciting dramatic series, Sundays, NBC-TV

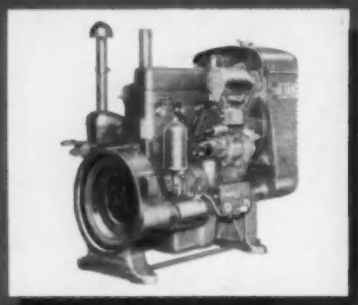
BLANKING • EMBOSSING • STAMPING • DRAWING • RIVETING

FORMING • ROLL SHAPING • TUBE BENDING • WELDING • BRAZING • FINISHING

To get the advantages that only 54 years of engine

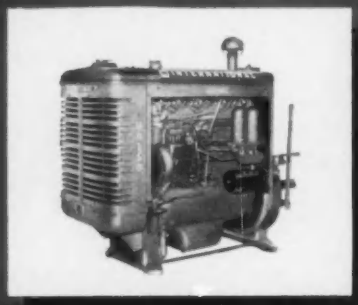
standardize on International

Here are 5 typical members of the International family of 18



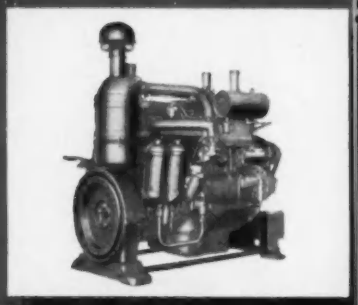
U-169

U-169, rugged 4-cylinder 48.6 hp valve-in-head carbureted unit, delivers top performance on "regular" gasoline. Can be adapted to burn LPG, natural gas, kerosene, or distillate. Ideal for compactors, ⅜-yd excavators, water well drills, fork lifts, rotary snow plows, 12 to 15 kw generators.



UD-350

UD-350, 4-cylinder diesel develops 78.5 bhp as an engine, 75 bhp as a power unit shown above. Available in air compressors, bucket loaders, asphalt mixers and driers, ½-yd shovels and cranes, portable screening plants, 25 to 40 kw generators, hoists, graders, pumps, and trenchers.



UD-525

UD-525, 6-cylinder, 121 bhp diesel with all-weather push-button starting as standard equipment. Available with 14 major attachments, including 43-gal fuel tank, muffler, skid-type subbase. Fits 29 different excavators, graders, compressors, other construction tools.

International power units in various modifications are engineered to team with all these machines:

Shovels, Cranes, Draglines
17 Manufacturers

Motor Graders
5 Manufacturers

Air Compressors
5 Manufacturers

Road Rollers
4 Manufacturers

Asphalt Mixers and Pavers
6 Manufacturers

Crushers
5 Manufacturers

Fork Lifts
3 Manufacturers

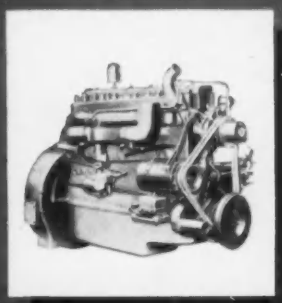
Generators
5 Manufacturers

Trenchers
3 Manufacturers

Pumps
12 Manufacturers

leadership can give . . .

Engines



U-450

UD-1091

U-450, one of the most popular 6-cylinder carbureted engines on the market today for trucks, water well drills, 35 to 50 kw generators, graders, ¾-yd shovels and draglines, big rotary snow plows, ditchers and trenchers. Develops 118.5 belt horsepower.

UD-1091, diesel, largest of the 18 International engines, develops 214 bhp, provides exceptional fuel economy for 34 different makes of construction units, including 2 to 2½-yd shovels, 8-cylinder compressors, large asphalt plants and 75 to 100 kw generators.

Engine Model	Displacement (Cubic Inches)	Horsepower (with full equipment less fan)
CARBURETED ENGINES		
U-1	60	17 @ 2500
U-123	123	31.2 @ 2000
U-169	169	48.6 @ 2000
U-264	264	53.5 @ 1600
U-220	220	64 @ 2400
U-240	240	66.5 @ 2400
U-282	282	79 @ 2400
U-372	372	96.5 @ 2200
U-406	406	104 @ 2200
U-450	450	118.5 @ 2200
U-1091	1091	214 @ 1600

Engine Model	Displacement (Cubic Inches)	Horsepower (with full equipment less fan)
DIESEL ENGINES		
UD-264	264	57.5 @ 1800
UD-350	350	78.5 @ 1800
UD-14A	461	100 @ 1800
UD-525	525	121 @ 1800
UD-140-D	525	141 @ 2300
UD-18A	691	131.5 @ 1600
UD-1091	1091	214 @ 1500

In most fields, you'll probably agree, you get the most for your money from the company that's been a leader *for the longest time*.

In engines and power units, the outfit to turn to for longest leadership is International. Since starting manufacture in 1902, International has built and sold *millions of engines* for heavy-duty work! In these 54 years, International has pioneered in developing and perfecting many of the features you consider essential today. Valve-in-head design . . . all-weather diesel starting . . . replaceable cylinder sleeves . . . tocco hardening . . . lubrication through drilled passages . . . precision type bearings . . . full-flow oil filters, to name a few.

These cost-cutting features are backed up with such added advantages as:

Honest horsepower ratings at speeds you can use.

Easy installation with attachments to fit whatever jobs you have.

Fully-experienced sales engineers to help you select and install the engine which best does your work.

Unmatched adaptability, with the same basic engine available as regular or optional power with various modifications in many kinds of equipment (one typical International engine, for instance, fits an International crawler tractor *and 46 makes* of loaders, compressors, asphalt mixers, pavers, excavators, generators, pumps, graders, and rollers). When you power with International, this ready adaptability lessens your parts inventory . . . simplifies and speeds operator training . . . makes your servicing problems a lot easier!

International engine owners get another tremendous benefit, too. To help them is one of the most experienced heavy-duty engine parts and service organizations in the world. At your service are 11 giant regional *parts depots*, 173 Industrial Power *Distributor* locations, *and* hundreds of Power Unit *Dealers*.

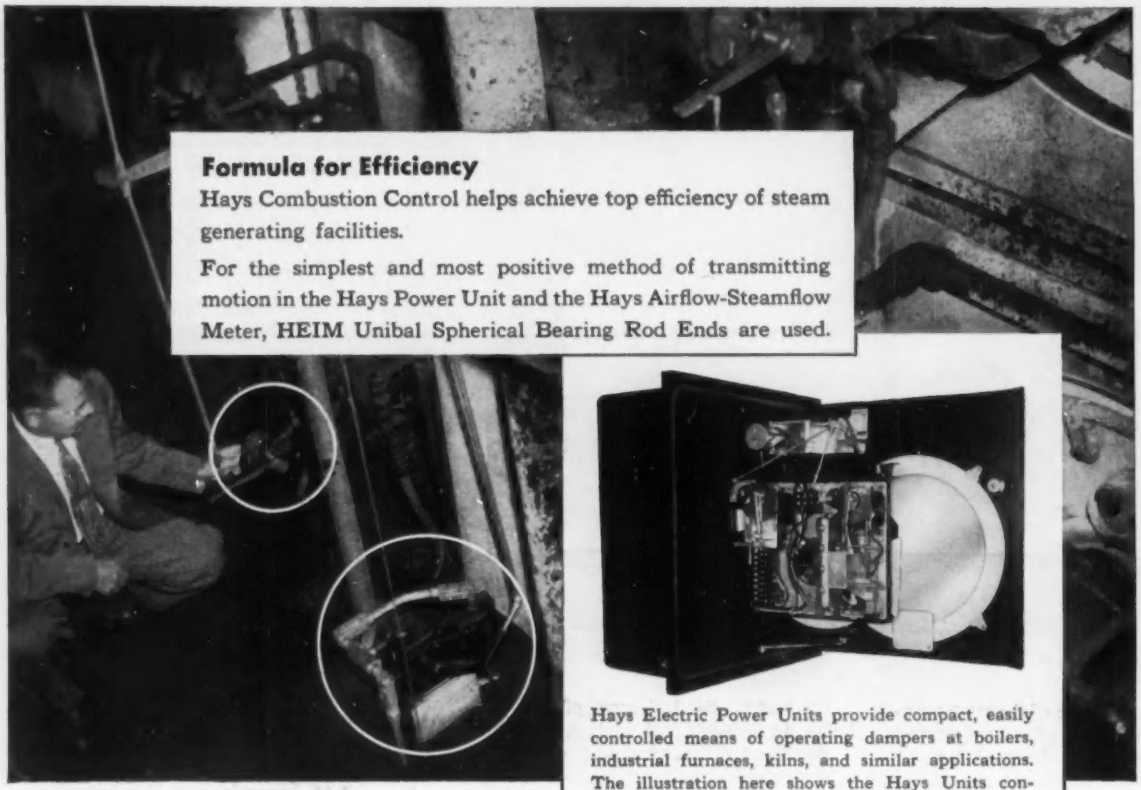
To get all these big profit-making advantages, be sure to specify International power. See your nearest Distributor or Dealer for all the facts.

INTERNATIONAL HARVESTER

International Industrial Power

180 N. MICHIGAN AVENUE—CHICAGO 80, ILLINOIS

A COMPLETE POWER PACKAGE INCLUDING: Crawler, Wheel, and Pipe-Boom Tractors . . . Self-Propelled Scrapers and Bottom-Dumps . . . Tractor and Rubber-Tired Loaders . . . Diesel and Carbureted Engines



Formula for Efficiency

Hays Combustion Control helps achieve top efficiency of steam generating facilities.

For the simplest and most positive method of transmitting motion in the Hays Power Unit and the Hays Airflow-Steamflow Meter, HEIM Unibal Spherical Bearing Rod Ends are used.

Hays Electric Power Units provide compact, easily controlled means of operating dampers at boilers, industrial furnaces, kilns, and similar applications. The illustration here shows the Hays Units controlling the fuel feed on two Pulverizers.

The HEIM *Unibal* ROD END

was developed to overcome the problem of misalignment in push-pull controls. It consists of a single ball bored through the center, bronze bearing inserts, and an outer member of steel or other suitable material.

This type of Unibal bearing presents a larger surface supporting area and carries greater radial and thrust loads. Because of the universal motion of the ball, the Heim bearing corrects any misalignment of the shaft in all directions.

HEIM ROD END

THE HEIM COMPANY
FAIRFIELD, CONN.

There is a brand new catalog of Heim bearings now ready. Please write for your copy.

REVERE
It is Revere's business to supply you with metals that can keep your production flowing smoothly. In Revere Aluminum Extrusions you get metals made with a skill that comes only from many years' experience, plus service and delivery that come from Revere's undivided interest in filling your needs. It will pay you to gear the progress of your business to the most dependable sources of supply.
ALUMINUM
Revere Aluminum Mill Products include extruded products; coiled and flat sheet, embossed sheet, circles and blanks; seamless drawn tube and welded tube; rolled shapes; electrical conductors; forgings; and foil. Call the nearest Revere Sales Office now. They are in all principal cities. Revere Copper and Brass Incorporated. *Founded by Paul Revere in 1801.* Executive Offices: 230 Park Avenue, New York 17, N. Y.
EXTRUSIONS
REVERE
ALUMINUM

PUMPS

DEVELOP OIL HYDRAULIC POWER

2 to 100 gpm—continuous duty operation up to 1500 psi—up to 1800 rpm—single or double rotation—constant delivery.

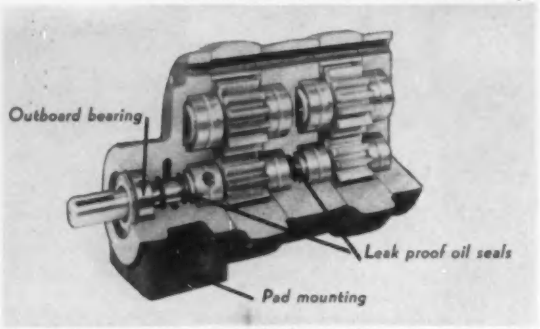


Fig. 1—Two gear pumps assembled in tandem on common shaft deliver independently—can be piped for dual operation or combined for double capacity single operation. "Pressure Pocketing" reduces slippage, friction and wear—volumetric and mechanical efficiency over 90%.

GEAR SIZE	SPEED (R.P.M.)	OUTPUT (G.P.M.) at discharge pressure psi 500	1000	1500	INPUT (H.P.) at discharge pressure psi 500	1000	1500
PC	600	2.3	1.1	0.5	1.2	2.3	3.5
SERIES	1200	4.5	3.6	2.6	2.4	4.5	7.0
1″	1800	7.2	6.0	5.5	3.8	6.7	10.5
PD	600	6.6	6.4	6.3	2.6	4.0	7.0
SERIES	1200	13.2	13.0	13.0	5.2	8.0	13.5
1″	1800	19.3	19.0	19.0	7.5	12.0	20.5
PJ	600	19.4	18.7	18.4	6.2	12.3	18.0
SERIES	1200	41.3	40.6	40.0	12.8	24.7	37.4
2″	1800	62.1	61.0	60.3	20.5	38.6	58.8

Performance data for PC and PD pumps having gear widths other than shown above can be approximated by multiplying values in above table by width of desired gear; for PJ pumps multiply by 1/2 the width of desired gear.

PC SINGLE PUMPS

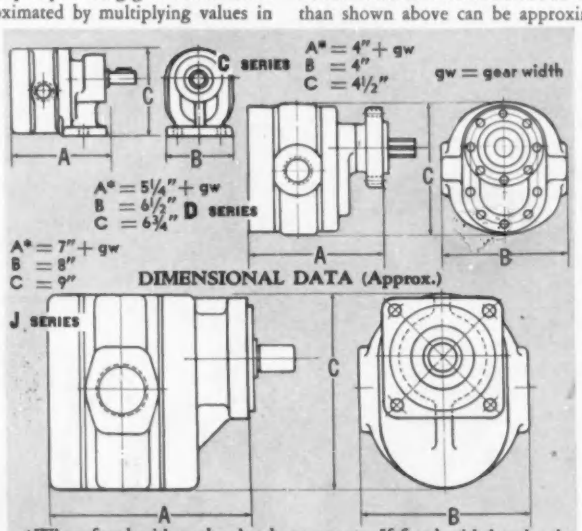
3 gear widths, 1/2″, 1″, 1-1/2″.
4 round shaft sizes.
pedestal and 3 flange mountings.
tapped ports—side or end.

PD SINGLE PUMPS

7 gear widths, 1/2″, 3/4″, 1″, 1-1/2″, 2″, 2-1/2″, 3″
8 round and 3 splined shaft sizes.
pad and 7 flange mountings.
tapped ports—side or end.

PJ SINGLE PUMPS

5 gear widths, 2″, 2-1/2″, 3″, 3-1/2″ and 4″.
1 round and 1 splined shaft size.
2 flange mountings.
tapped or split flange side portings.



*When fitted with socket head cap screws. If fitted with hex head cap screws add thickness of head.

MOTORS

UTILIZE OIL HYDRAULIC POWER

2 to 68 hp—continuous duty operation up to 1500 psi—up to 1500 rpm—single or double rotation—variable speed.

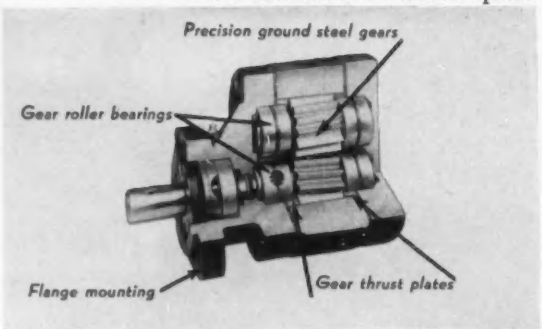


Fig. 2—Single gear motor can be piped from side on end ports. Extra large gear bearings maintain shaft alignment; heavy-duty outboard bearing absorbs drive shaft and shock loadings. New leakproof oil seals maintain internal pressure balance.

GEAR SIZE	SPEED (R.P.M.)	INPUT (G.P.M.) at input pressure psi 600	1000	1500	OUTPUT (H.P.) at input pressure psi 600	1000	1500
MC	600	0.8	1.4	2.4	4.1	4.7	5.3
SERIES	1000	1.3	2.4	3.4	7.1	7.4	7.7
1″	1500	1.9	3.5	4.5	9.6	10.4	10.8
MD	600	2.1	3.5	4.3	8.2	8.6	9.0
SERIES	1000	3.5	5.8	8.0	12.5	13.6	14.0
1″	1500	4.3	8.0	11.2	18.0	19.0	20.0
MJ	600	5.7	10.2	15.5	21.3	21.8	23.3
SERIES	1000	8.7	15.8	24.9	34.2	35.4	36.9
2″	1500	10.2	21.5	34.3	54.0	55.0	57.5

Performance data for MC and MD motors having gear widths other than shown above can be approximated by multiplying values in above table by width of desired gear; for MJ motors multiply by 1/2 the width of desired gear.

MC SINGLE MOTORS

3 gear widths, 1/2″, 1″, 1-1/2″.
4 round shaft sizes.
pedestal and 3 flange mountings.
tapped ports—side or end.

MD SINGLE MOTORS

7 gear widths, 1/2″, 3/4″, 1″, 1-1/2″, 2″, 2-1/2″, 3″.
8 round and 3 splined shaft sizes.
pad and 7 flange mountings.
tapped ports—side or end.

MJ SINGLE MOTORS

5 gear widths, 2″, 2-1/2″, 3″, 3-1/2″ and 4″.
1 round and 1 splined shaft size.
2 flange mountings.
tapped or split flange side portings.

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VALVES

CONTROL OIL HYDRAULIC POWER

1/2"—20 gpm capacity, 3/4"—35 gpm capacity, 1"—60 gpm capacity—operating pressure up to 2000 psi non-restricted full flow parallel circuiting.

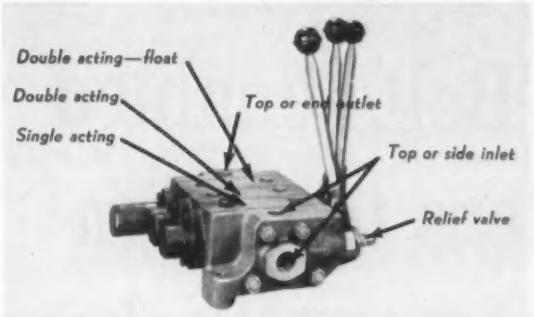


Fig. 3—Multiple directional control valve consisting of five manifold sections assembled into a unit. Any combination of operating manifolds, even up to a dozen or more, can be assembled into a single space saving unit.

MANIFOLD SECTIONS

INLET MANIFOLDS

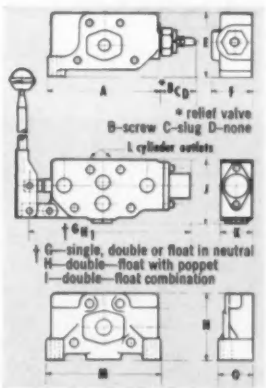
Side or top connections.
Screw or slug type relief valve, or without built-in relief valve.

OPERATING MANIFOLDS

Single acting, double acting, double acting float in neutral and double acting float in hold position.
Built-in positive hold check prevents load drop.

OUTLET MANIFOLDS

Tapped connections to provide for top or side return to tank, pressure beyond or direct bottom dump into tank.



APPROXIMATE OVERALL DIMENSIONS (IN.)

SIZE	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
½"	7	2¼	1	⅛	4 1/16	2½	10	12 1/16	13	3⅞	2	½	7¼	4 1/16	2¼
¾"	8	2¼	1	⅛	4 ⅞	2¾	11 3/16	13 ⅜	14 3/16	4¾	2½	¾	8¼	4 ⅞	2⅝
1"	10	3	1	1⅛	6 ½	3½	14	17 ⅛	17 ¾	6¼	3	1	10½	6 ½	3¼

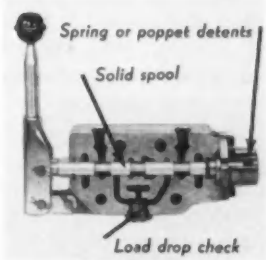
CHECK THESE FEATURES

FEATHER TOUCH OPERATION

Spools always in hydraulic balance provide extremely fine throttling for precision control.

NO LOAD DROP

Positive hold check built into every operating manifold section.



CYLINDERS

UTILIZE OIL HYDRAULIC POWER

single acting, double acting, telescopic capacity up to 25 tons—stroke up to 45 inches operating pressure up to 1500 psi.

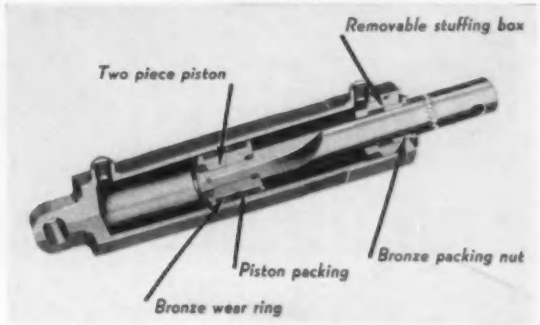


Fig. 4—Double acting solid plunger cylinder fitted with two piece piston. Disassembly for easy inspection and replacement of piston or stuffing box packings is a simple field operation. Note there is no metal to metal contact between piston and cylinder.

DOUBLE ACTING

ROD. DIAMETER		1	1¼	1¼	1½	1½	2	2	2½	2½
CYLINDER O.D.		2½	2⅞	3	3⅞	4⅞	5⅞	6⅞	8	9¼
DISPLACEMENT	PUSH	.014	.017	.021	.036	.061	.094	.133	.179	.242
	PULL	.010	.012	.016	.028	.054	.080	.119	.158	.220
EFFECTIVE AREA	PUSH	3.1	4.0	4.9	8.3	14.2	21.6	30.7	41.3	55.9
	PULL	2.4	2.7	3.7	6.5	12.4	18.5	27.5	36.3	50.9

SINGLE ACTING

PLUNGER DIA.	1	1½	1¾	2	2½	2¾	3¾	4¾	5¾	6¾	7⅞
CYLINDER O.D.	1⅞	2⅜	2⅝	2⅞	3½	3⅞	4⅞	5⅞	6⅞	8	9¼
DISPL'CM'T	.003	.008	.010	.014	.021	.026	.048	.077	.112	.155	.210
EFF. AREA	0.8	1.8	2.4	3.1	4.9	5.9	11.0	17.7	26.0	35.8	48.7

TELESCOPIC

2 SLEEVE

CYL. O.D.		4⅞	5⅞	6⅞	8	9¼
SLEEVE DIA.	1ST	3¾	4¾	5¾	6¾	7⅞
	2ND	2¾	3¾	4¾	5¾	6¾
DISPL'CM'T		.037	.062	.095	.133	.183

3 SLEEVE

CYL. O.D.		5⅞	6⅞	8	9¼
SLEEVE DIA.	1ST	4¾	5¾	6¾	7⅞
	2ND	3¾	4¾	5¾	6¾
	3RD	2¾	3¾	4¾	5¾
DISPL'CM'T		.050	.079	.115	.159

4 SLEEVE

CYL. O.D.		6⅞	8	9¼
SLEEVE DIA.	1ST	5¾	6¾	7⅞
	2ND	4¾	5¾	6¾
	3RD	3¾	4¾	5¾
	4TH	2¾	3¾	4¾
DISPL'CM'T		.066	.098	.139

5 SLEEVE

CYL. O.D.		8	9¼
SLEEVE DIA.	1ST	6¾	7⅞
	2ND	5¾	6¾
	3RD	4¾	5¾
	4TH	3¾	4¾
	5TH	2¾	3¾
DISPL'CM'T		.083	.121

Figures in tables shown in units as follows: diameter—inches, area—square inches capacity—pounds, pressure—lbs. per sq. in. displacement—gallons per inch of stroke

EFFECTIVE AREAS OF SLEEVES

SLEEVE DIAMETER	2¾	3¾	4¾	5¾	6¾	7⅞
EFFECTIVE AREA	5.9	11.0	17.7	26.0	35.8	48.7

Cylinder capacity, neglecting friction loss, can be approximated by multiplying rod, plunger or sleeve effective area by operating pressure.

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Pumps · Motors · Valves · Cylinders

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COMMERCIAL shearing and stamping

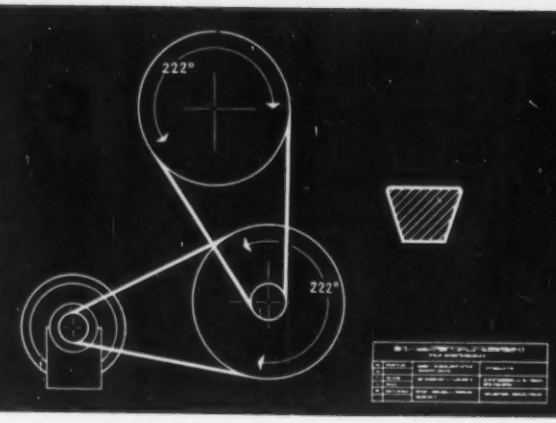
How Dayton V-Belts enabled appliance makers to design more efficient, compact Washers and Dryers of higher styling!

Case History Spec. No. K12078

The Problem: Obtain peak drive performance for new automatic dryer designed with a highly restricted speed range heretofore impractical. Reduce inherent drive noise.

The Approach: Develop special V-Belts and build test machines which will duplicate exact dryer conditions.

The Solution: New V-Belt 100% effective in maintaining desired speed within required limits, elimination of drive noise.



Dayton V-Belt turns dryer drum, silently, at exact speed required to produce dry, fluffy clothes.

Case History Spec. No. K12078 relates the successful efforts of one major appliance manufacturer to maintain and hold dryer speed within its most efficient range.

The Problem:

1. To develop a dryer V-Drive capable of maintaining drum speed within rigid range limitations.

2. In addition, to neutralize inherent noise caused by a floating idler type assembly confined in a metal cabinet.

Approach to Solution:

1. After consultation with appliance designer engineers and review of specifications, Dayton V-Belt engineers made recommendations regarding tolerances for pulley groovings and motor speeds.

2. Test machines were then developed, at Dayton Rubber, so calibrated that infinite speed differentials could be measured in checking sample V-Belts at precise speeds.

3. V-Belt samples were then produced to reach and maintain close speed tolerances.

4. Alterations in cross-section and construction followed to build samples capable of operating within specific speed requirements, pulley diameters, tolerances, tensions, etc.

5. New samples met all speed restrictions perfectly—only one problem remained: Elimination of noise.

6. Further refinement in V-Belt design and construction produced a noiseless V-Belt drive.

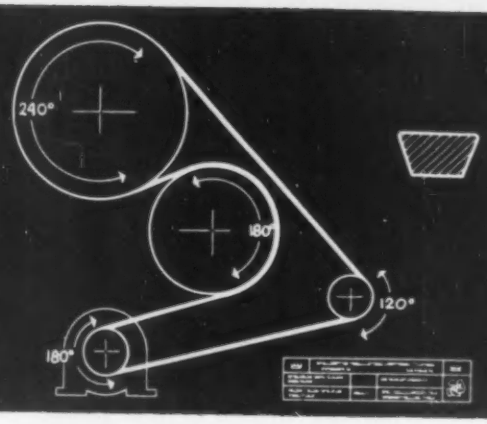
7. Result: The new automatic dryer operated *continuously* and silently, at the exact speed desired for most effective performance, thanks to Dayton V-Belts and Dayton V-Belt engineering assistance.

Case History Spec. No. L14133

The Problem: Tortuous back bend, limited take-up area plus small pulleys combine to create unusually rugged conditions for V-Belt drive on washer.

The Approach: Build new, highly flexible V-Belt with low-stretch qualities and high co-efficient of friction.

The Solution: New belt maintains tension, eliminates vibration and "stays put" within adjustable limits.



Spec. No. L14133 highlights advantages of Dayton engineering on multiple-feature drives.

The Problem:

Washer drive specifications called for V-Belt to operate over small pulleys subjected to a tortuous back-bend in driving spinning drum.

The Approach to Solution:

In designing a V-Belt with the necessary flexibility and tension to operate on the small pulleys and take the terrific back bend it was also necessary to provide a smooth back surface on the belt to insure against vibration.

The Solution:

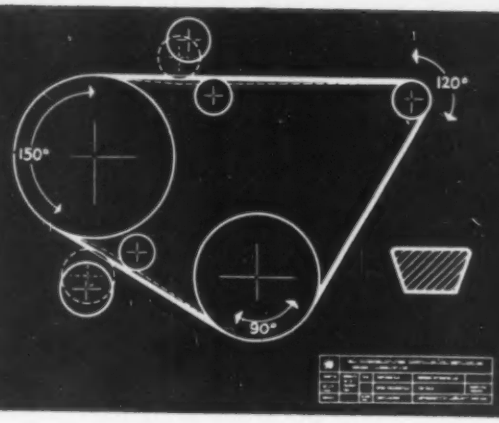
Special cords and new internal belt construction provide the answer. Smooth contact with spinning drum was solved by a special V-Belt manufacturing process exclusive with Dayton Rubber.

Case History Spec. No. D13912

The Problem: To obtain maximum power transmission for washer employing V-Belt in restricted space over sub-diameter pulleys.

The Approach: Explore possibilities for developing a V-Belt with unusually low stretch factor.

The Solution: New V-Belt produced for present production. Follow-up research and development instituted for later improved models.



Spec. No. D13912 emphasizes value of engineering assistance of automatic washer drive.

The Problem:

Space limitations required V-Belt transmit full power over extremely small sub-diameter pulleys without slippage.

Approach to Solution:

1. Experimental V-Belts were built with a high degree of flexibility to provide greater grip on sub-diameter pulleys and in addition, made assembly easier.

2. Special low-stretch cord was processed and incorporated to maintain tension throughout V-Belt life.

3. Laboratory and field tests proved dependability of new V-Belt and assured long service life.

The Solution:

A V-Belt was produced rugged enough to meet *every* requirement of the new automatic washer.

Further Development:

The solution was only the beginning for Dayton. Continued research and testing were begun at once to meet other new operational requirements for later models.

These Case Histories typify the close engineering assistance available from Dayton's experienced staff of V-Belt engineers. For assistance in improving your appliance write: Dayton Rubber Co., Industrial O.E.M. Div., Dayton 1, Ohio.

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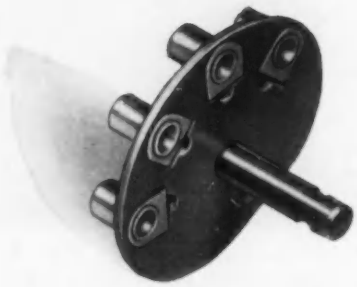
Dayton Rubber 51 YEARS OF PROGRESS

WORLD'S LARGEST MANUFACTURER OF V-BELTS

MALLORY



Typical of the many switch designs Mallory has developed is this rotary voltage change switch for electric motor service, to connect field windings in series or parallel.

Your "Special" Switch Problems Solved Economically...by Mallory

A LOT of expert attention to design details goes into the numerous types of Mallory switches. Take the motor voltage change switch illustrated here. Its silver plated phosphor bronze stator contacts are built to assure constant contact tension and maximum electrical conductivity. The whole assembly, though simple in appearance, is engineered for extra ruggedness to withstand severe vibration encountered in motor service.

Whether your product calls for a simple or complex switch . . . rotary, push-button, plunger or special type . . . it pays to see what Mallory can offer you. In cooperation with leading manufacturers, our staff of switch specialists have developed a broad range of standard designs, readily produced with existing tooling. One of these may exactly match your product requirements . . . at a cost that can provide real savings. And if your needs are for something out of their range of standard types, Mallory engineers are thoroughly qualified by experience to create custom-fitted designs.

Standard or custom-made, the switches you get from Mallory give you many extra values.

Count on Mallory for performance . . . founded on ingenuity in mechanical design, and on utilization of Mallory's special experience in contact alloys.

Count on them for economy . . . the result of precision production in Mallory's modern, high-volume manufacturing facilities.

Count on them for ready availability. Mallory production is geared for prompt delivery to meet your schedules.

Write or call Mallory today for a consultation on your own product's switch requirements.

Expect more...get more from

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Electromechanical—Resistors • Switches • Tuning Devices • Vibrators
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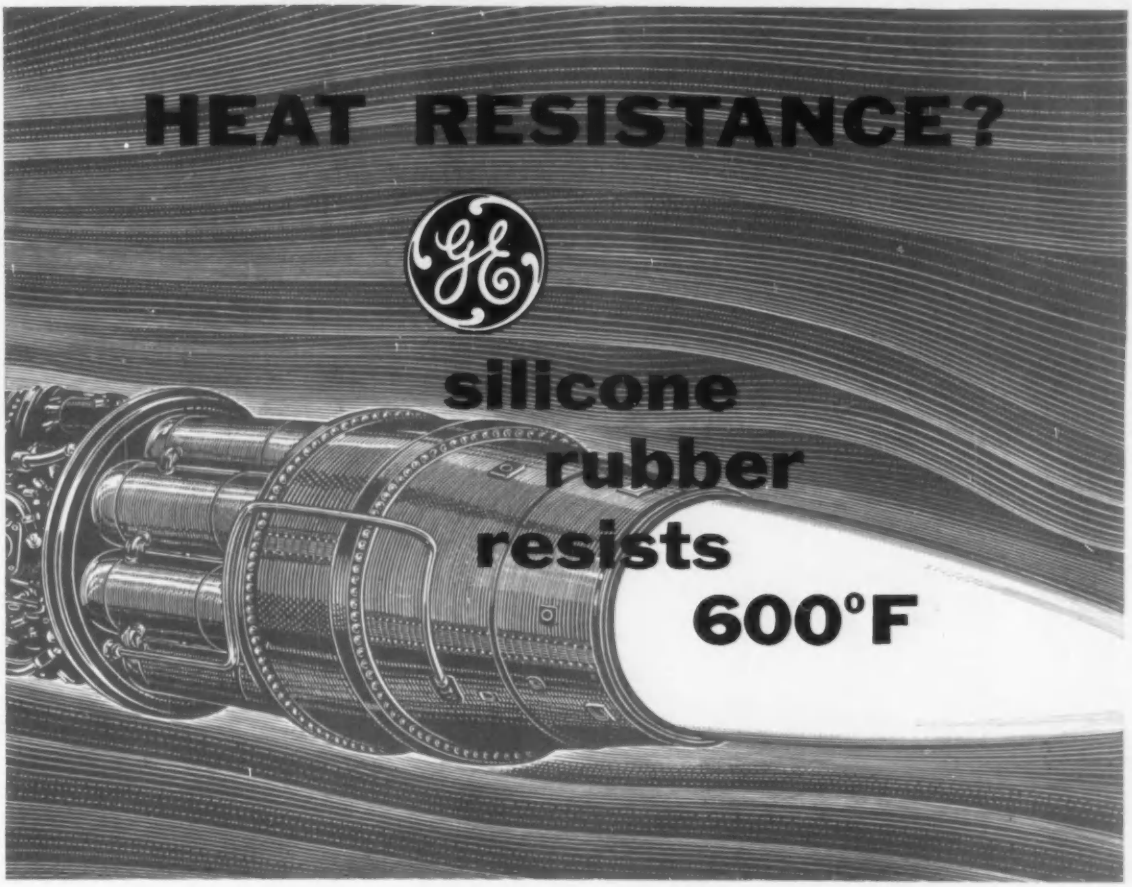


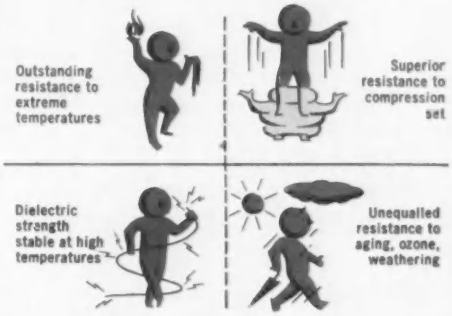
Looking for *really* heat-resistant rubber? General Electric's Class 700 silicone rubber offers serviceability *up to 600 F!* That's why it's being used for aircraft ducting and oven door seals subject to *intermittent* temperatures of 600 F. And it provides *continuous* service at 300-500 F as seals and gaskets in jet engines, diesel engines, clothes dryers, electric cookers, steam irons and heat sealing equipment.

Where can YOU use G-E silicone rubber?

There's a kind for almost every requirement, classified according to dominant property for easy selection and specification. For example: Class 300 offers the best recovery after compression *of any known rubber!* Class 500 provides flexibility *at 150 F below zero!* Which class is best for *you?*

For more details on G-E silicone rubber, see your "Sweet's Product Design File."

G-E silicone rubber provides...


Outstanding resistance to extreme temperatures
Superior resistance to compression set
Dielectric strength stable at high temperatures
Unequalled resistance to aging, ozone, weathering

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SILICONE PRODUCTS DEPARTMENT **SECTION 61-3D**
GENERAL ELECTRIC COMPANY **WATERFORD, NEW YORK**

Please send me, at no obligation, technical data on G-E silicone rubber, including a newly revised "Lightning Selector" and up-to-date list of fabricators.

Name_____ Position_____

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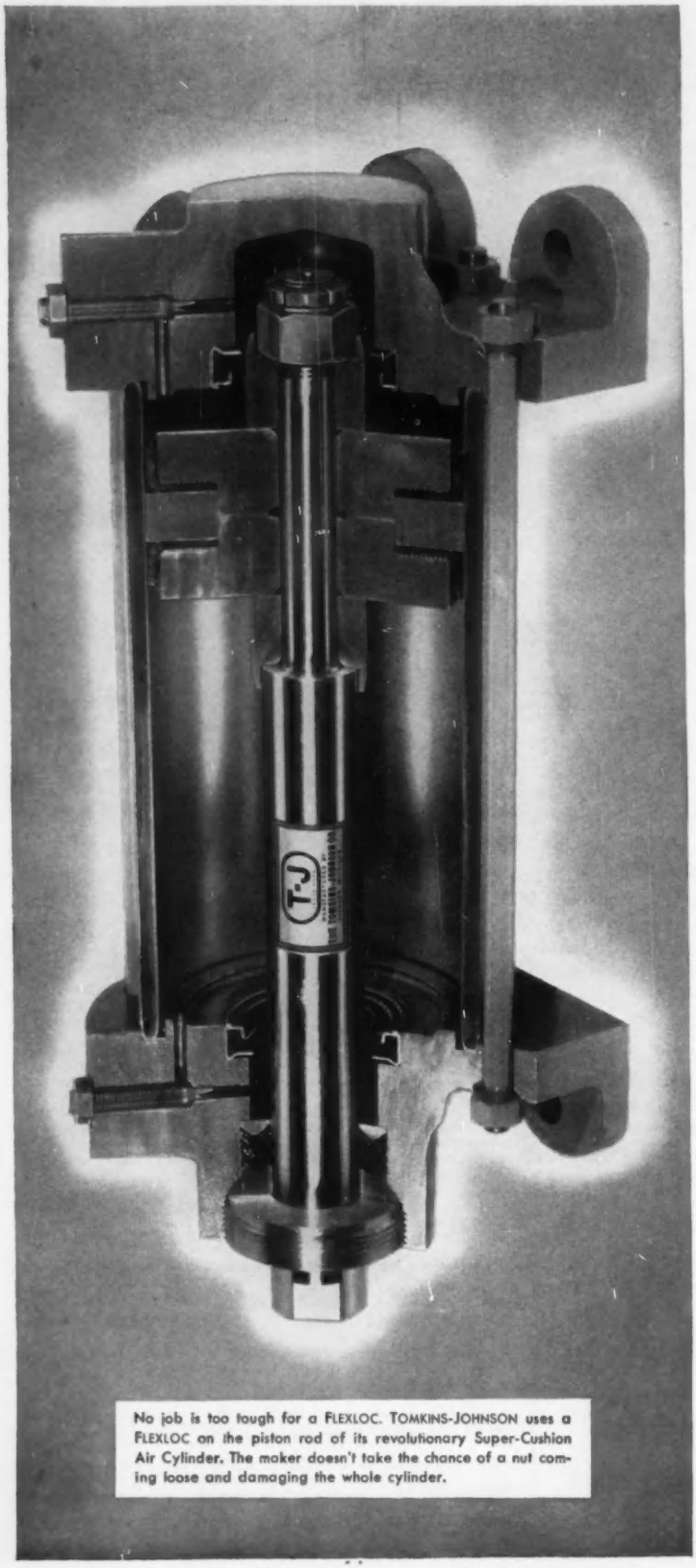
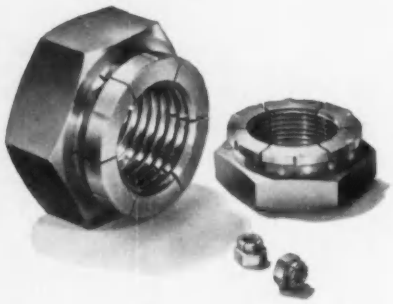


No job is too tough for a FLEXLOC. TOMKINS-JOHNSON uses a FLEXLOC on the piston rod of its revolutionary Super-Cushion Air Cylinder. The maker doesn't take the chance of a nut coming loose and damaging the whole cylinder.



What FLEXLOC locknuts do for you

FLEXLOCs eliminate complicated, time-consuming methods of locking threaded fasteners. They offer simpler, faster application and safer, more dependable locking than plain nuts and lockwashers, castellated nuts and cotter pins, or nuts and jam nuts. And they won't work loose.

The reasons for all this are plain. FLEXLOCs are one piece—nothing to assemble, come apart, lose or forget. FLEXLOCs are all metal—have higher tensile than most other locknuts and are not affected by temperatures to 550°F. FLEXLOCs are both stop and locknuts—don't have to seat to lock, and stay put anywhere on a threaded member as soon as their locking threads are fully engaged.

SPS can deliver any quantity of FLEXLOCs in a wide range of sizes. Stocks are carried by industrial distributors everywhere. Write for literature. SPS, Jenkintown 28, Pa.

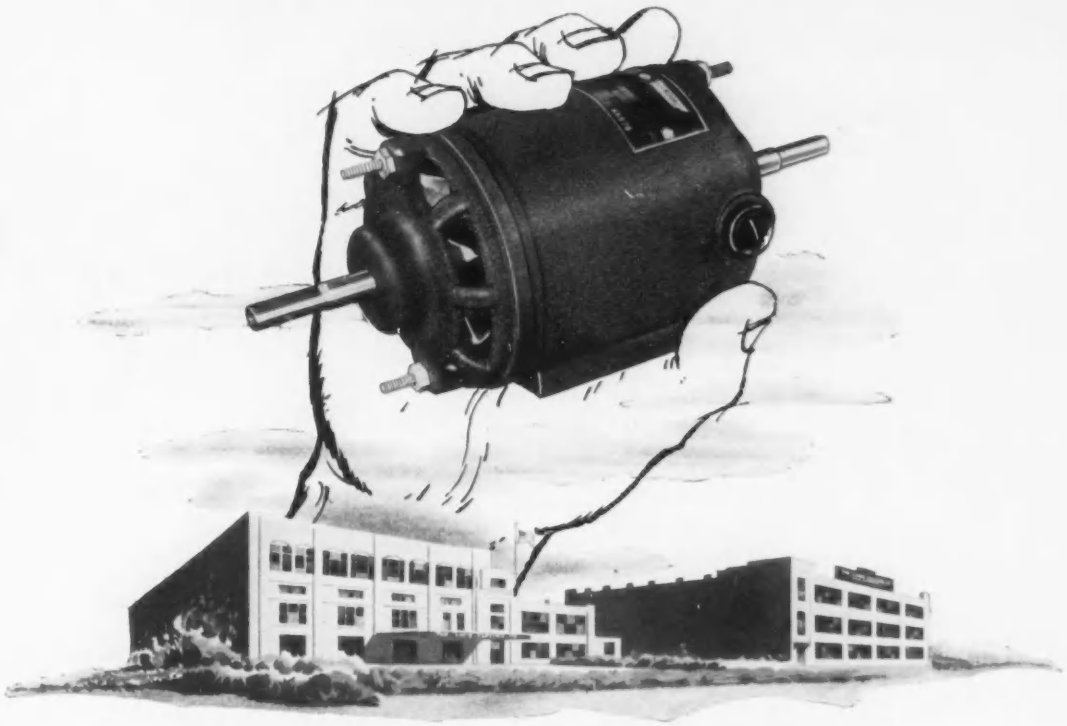
FLEXLOC®

LOCKNUT DIVISION

STANDARD PRESSED STEEL CO.

SPS

JENKINTOWN PENNSYLVANIA



CUSTOM-BUILT USE-ABILITY...

for your motor-driven products

Exceptional performance and dependability go with useability in Lamb Electric Motors because they are:

(1) "tailored" to the exact requirements of an application.

(2) built of quality materials by precision-minded personnel.

Our company is equipped and organized to *custom-manufacture on a volume basis;* hence high quality and controlled costs go hand-in-hand.

We would like to discuss these advantages with you for *your* new and redesigned products.

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Swivel-mounted portable tool motor.

Aircraft de-icing pump motor.

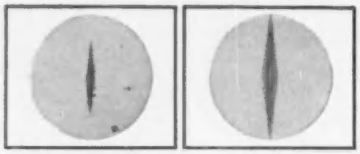
Gear motor for slow-speed drive.

Turbine for canister-type vacuum cleaner.

If you are interested in any of the motors at left write and we shall be glad to send full information.

A composition that is almost twice as hard as the hardest steel . . . KENNAMETAL*

Kennametal is the registered trademark of a series of hard alloys of tungsten, tungsten-titanium, and tantalum carbides. These compositions are the *hardest* practicable metals made by man. In scratch hardness tests, these hard carbide particles are between sapphire and diamond. On the Rockwell "A" Scale, different Kennametal grades test from 90.0 to 93.0, while that of HSS 18-4-1 heat-treated steel tests a maximum of 85.0. The Knoop Test

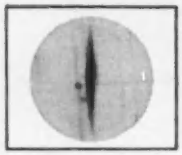


K8 Tungsten carbide — 18-4-2 Steel

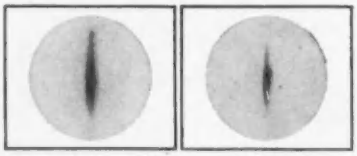
gives 2100 (K100) for Kennametal and 800 (K100) for steel.

Photomicrographs above show results of Knoop hardness test on Kennametal K8 (left) and HSS 18-4-2 steel (right) at 100g. Impression in the Kennametal is only about half of that on the steel.

Photomicrographs below are of Knoop tests on grains of carbide ingredient of Kennametal. Knoop test numbers (at 100g) are: tungsten carbide, 1900; tungsten-titanium carbide, 2200; titanium carbide, 2500. These tests show those carbides are from two to three times as hard as steel in the absolute scale of Kgs per square mm of area of impression.



Tungsten carbide

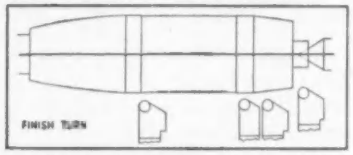


Tungsten-titanium carbide — Titanium carbide

Extreme Hardness of KENNAMETAL Utilized by Designers

A West Coast manufacturer switched to solid Kennametal tungsten-titanium carbide tools for internal threading of stainless steel rings, jumped production from 35 to 40 pieces between grinds to 80 to 100 pieces with Kennametal. And the latter showed no cratering and only slight edge wear requiring only light grinding.

A manufacturer of aircraft landing gears uses the hardest grade of Kennametal cutting edges for interrupted cutting of SAE-4340 steel (220,000 psi tensile strength), at 1 ½ times greater speeds and with over 10 times longer tool life. Both sides of 54 pieces are rough cut and finish cut between grindings.



2400 to 3600 (depending on shell hardness) 90 mm shells are finished-turned using the hardest grade Kennametal before regrinding is required.

Perhaps KENNAMETAL's Extreme Hardness Can Help You, Too

Together with absolute hardness goes surprisingly greater resistance to wear and deformation. It is vital to innumerable industrial applications. Perhaps it is the characteristic you need to get YOUR idea off the drawing board and into production. It is worth investigating. Write to KENNAMETAL INC., Latrobe, Pennsylvania, and ask for Booklet B-111.

*Registered Trademark

SEE OUR EXHIBIT
Booth 313
at the Design Engineering Exposition
MAY 14-17
Convention Hall
Philadelphia, Pa.

Come in and visit us while you are in Philadelphia. See "live" demonstrations that prove the many outstanding characteristics of Kennametal and Kentanium (the titanium carbide for application at 1800° F and above). See such demonstrations as:

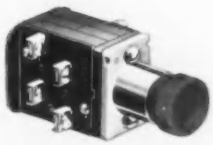
- The Torque Test
- The Hardness Test
- The Deflection Test
- The Vibration and Chatter Tests

Inspect dozens of sample machine and processing equipment parts made from Kennametal and Kentanium . . . typical applications being used in practically every industry. Our engineers will be glad to talk over any of your problems and advise how you may use these hard, strong metals to advantage.

B-5026

INDUSTRY AND
KENNAMETAL
. . . Partners in Progress

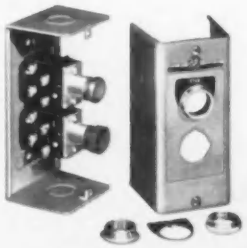
ALLEN-BRADLEY
HEAVY DUTY PUSH BUTTONS



Bulletin 800 heavy duty STOP button ready to mount in enclosure. (See below)

These new Bulletin 800 heavy duty push buttons are the modernized version of that old reliable line of A-B heavy duty stations. Advantages—until now restricted to the oiltight stations for machine tool use—have been built into these new heavy duty stations—and you'll like the result.

For instance, each button or pilot light is a self-contained unit which can be mounted singly or in groups—vertically or horizontally—in a variety of standard Allen-Bradley enclosures, with the name plate reading in the right direction. Double break, silver alloy contacts used throughout. Send for Bulletin 800.



A small stock of standard components lets you assemble any special heavy duty station. There is no waiting for special push button stations.

5-56-MR

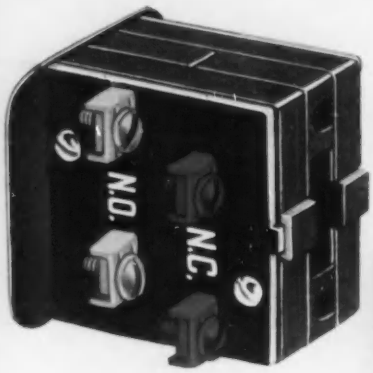
Allen-Bradley Co., 1316 S. Second St.
Milwaukee 4, Wisconsin

In Canada
Allen-Bradley Canada Ltd., Galt, Ont.

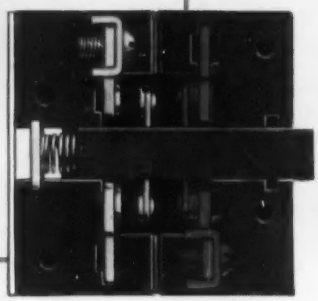
A-B Quality

ALLEN-BRADLEY
QUALITY

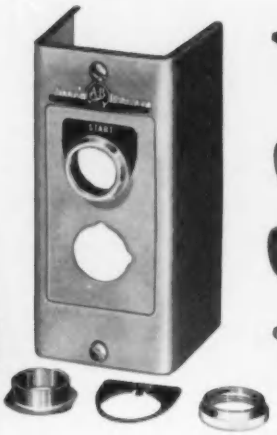
BULLETIN 800 PUSH BUTTONS

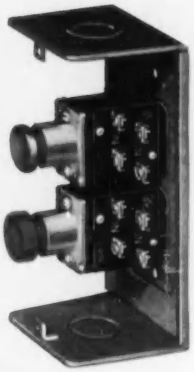


Left—External view of contact block showing N. O. & N. C. terminals.



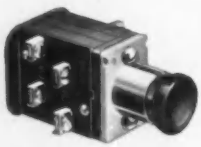
Right—Internal view of contact block showing double break N.O. & N.C. stationary contacts. The pushrod carries the moving contacts.



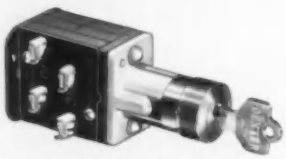


Two button station with name plate and clamping ring removed from cover.

A NEW LINE OF ALLEN-BRADLEY HEAVY DUTY PUSH BUTTONS

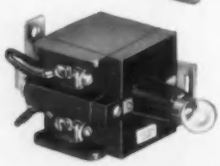


Type AK1B flush head START button



Type EK11B cylinder lock unit

Type HK11B wing lever selector switch unit



Type PK16 pilot light with 110 v, 60 cy. transformer. Available with 220-440-550 v, 60 & 25 cy. transformer

Allen-Bradley heavy duty push buttons have been redesigned to take advantage of the type of construction that has made A-B oiltight machine tool stations so popular.

While the new Bulletin 800 heavy duty line is not oiltight, it uses contact blocks that have proved so dependable in the Bulletin 800T oiltight push buttons. Special heavy duty stations can be assembled on the job from a small stock of standard components.

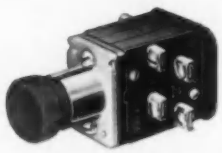
Several types of operators are available, such as standard head, mushroom head, coin slot, key type, wing lever, and 2 or 3 position selector switches. The buttons can be supplied in different colors.

These push button stations can be easily arranged for either vertical or horizontal mounting —with the name plates reading correctly for the desired mounting.

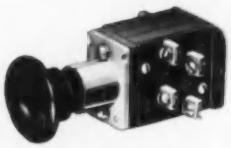
Standard enclosures accommodate up to 8 buttons and pilot lights. Enclosures for more than 8 units can be supplied. Write for Bulletin 800.

Allen-Bradley Co.
1316 S. Second St.
Milwaukee 4, Wis.
In Canada
Allen-Bradley Canada Ltd.
Galt, Ont.

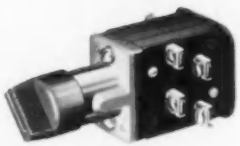
Five button station with pilot light



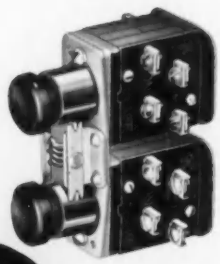
Type BK6B ext. head STOP button



Type DK6B mushroom head button



Type HK2B selector switch



Type FK2B 2 button interlocked station

ALLEN-BRADLEY
QUALITY
MOTOR CONTROL

5-56-MR

A Timely Word to Drafting Department Heads...

NOW* Is the Time to Get Your New Modern Bruning Copyflex Machine!

✻ **Because you'll need greater print-making capacity to meet the push for more drafting room output!**

✻ **Because your old reproduction unit can't keep pace with increased demands!**

✻ **Because, with management's desire for greater production, you can get top level approval for new equipment!**

You Need It! The boom in production means more pressure than ever for engineering prints. Modern Copyflex will help you deliver them! New, better-than-ever models bring you faster reproduction speed and a host of operator conveniences to step up production.

You Want It, Surely! Take this opportunity to replace that old, inadequate unit with efficient, trouble-free Copyflex—no exhaust venting, no plumbing or auxiliary equipment, no installation other than an electrical connection.

You Can Get It! Chances are that your firm, like most others, is gearing up for greater-than-ever production. You couldn't pick a better time to include new, higher-production equipment in your program. There's a new, improved Copyflex model to suit every price and production requirement. Mail coupon today. You'll be glad you did!

NEW COPYFLEX MODEL 500

A new, ultra-fast, heavy-volume machine offering top mechanical speed of 40 f. p. m., automatic separation, front or rear delivery, automatic stacking, and a host of other advanced features.

Three Other New, Improved Copyflex Models

Model 250. Newest and finest of its size. Takes less than a sq. yd. of floor space. Up to 25 f.p.m. speed —18½" printing width. Automatic stacking and separation.

Model 35. Provides up to 30 f. p. m mechanical speed and a full 46-inch printing width for heavy volume reproduction—at a thrifty, low price.

Model 100. The helper your big machine needs. Makes up to 300 prints of one or many different 8½" x 11" originals per hour—at less than 1¢ each for materials.

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Specialists in Copying Since 1897

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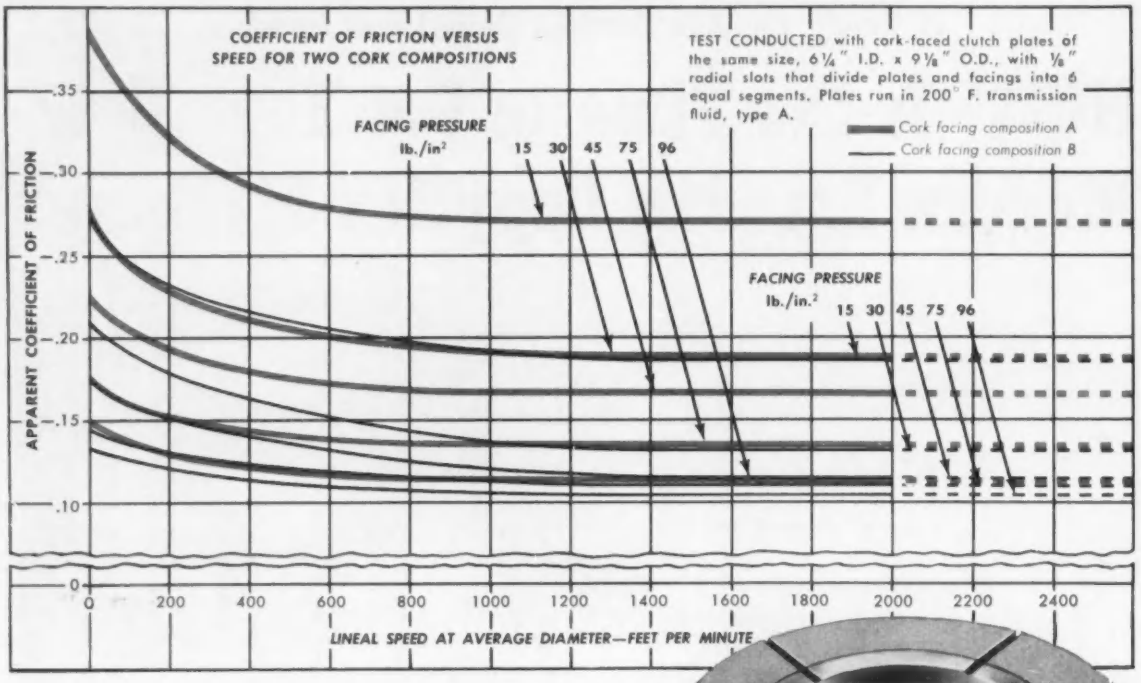
Please send me information on Copyflex process and____Model 500 ____Model 250____Model 35____Model 100.

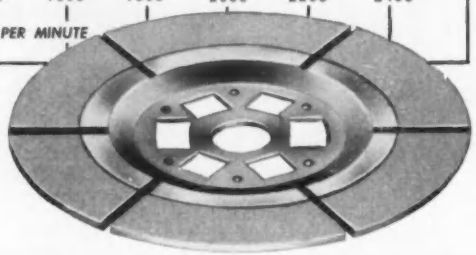
Name_____ Title_____

Company_____

Address_____

City_____ County_____ State_____


COEFFICIENT OF FRICTION VERSUS
SPEED FOR TWO CORK COMPOSITIONS
TEST CONDUCTED with cork-faced clutch plates of the same size, 6 1/4" I.D. x 9 1/8" O.D., with 1/8" radial slots that divide plates and facings into 6 equal segments. Plates run in 200° F. transmission fluid, type A.
Cork facing composition A
Cork facing composition B
FACING PRESSURE lb./in²
15 30 45 75 96
FACING PRESSURE lb./in.²
15 30 45 75 96
APPARENT COEFFICIENT OF FRICTION
.35
.30
.25
.20
.15
.10
0
0 200 400 600 800 1000 1200 1400 1600 1800 2000 2200 2400
LINEAL SPEED AT AVERAGE DIAMETER—FEET PER MINUTE



CORK CLUTCH FACINGS:

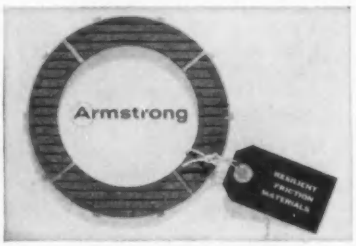
How changes in cork compounds affect torque capacity

Cork compound friction materials are unique in the high torque capacity they deliver. Just as valuable to designers, however, is the fact that this capacity can be greatly modified by changes in the cork composition.

Cork clutch facings can be compounded with a variety of resins, fibers, and rubbers. Because of this, an extremely wide range of different cork compounds is available, with each compound offering somewhat different properties. This means that designers can usually find a cork facing material that will deliver the exact performance required.

The chart above shows the values developed by two clutch plates identical in all respects—except for the facing compound. Because the metal plates were of the same design and size, the frictional patterns of both are similiar. But the apparent coefficients of friction produced by composition A are higher than those produced by composition B.

This wide range of torque capacities is only one of many unique advantages offered by cork compound friction materials. More facts on these materials are in the booklet shown at the right.



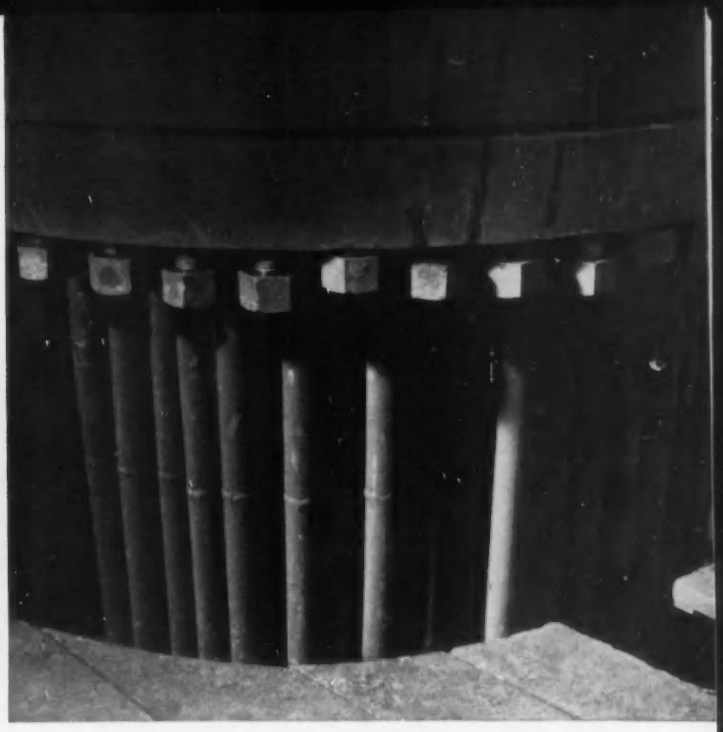
NEW 16-PAGE BOOKLET

For more information on the design versatility of cork compound friction materials, send for a copy of "Armstrong Resilient Friction Materials." This 16-page booklet is illustrated with many helpful charts and graphs and will be a useful source of information for your files. Write to Armstrong Cork Company, Industrial Division, 7205 Irvin Street, Lancaster, Pennsylvania.

Armstrong FRICTION MATERIALS

. . . used wherever performance counts

FOR SCUFF-RESISTANT BEAUTY. This Sunroc water cooler has, as standard equipment, a Stainless Steel kick plate for protection against scuffing and corrosion when floors are mopped. The deep drawn top is also made from Stainless. It's bright and inviting, and easy to clean.



FOR LONG, HARD SERVICE. Some of the Stainless Steel tubes in this bundle are 20 years old, despite the fact that they have been in continual service in a thermal cracking unit at a major southwestern oil refinery. Even though some of them have been lengthened by heliarc welding, they still retain their ability to handle corrosive products.

NOTHING *can equal* *Stainless Steel*

FOR SANITATION. This is a Stainless Steel rotary washer at a baby food plant of Gerber Products Company. Stainless Steel was used because of its great corrosion resistance, because it will not contaminate the food products, because it is so very easy to clean. Gerber's uses a lot of Stainless Steel processing equipment—including peelers, bins, steamers, holding tanks and filling machines.

• No other design material can match Stainless Steel in its *combination* of desirable properties: corrosion resistance, strength and hardness, beauty, cleanability and easy fabrication. When seeking a source of supply, remember that United States Steel offers the widest range of types, finishes and sizes available in the United States.

UNITED STATES STEEL CORPORATION, PITTSBURGH • AMERICAN STEEL & WIRE DIVISION, CLEVELAND
COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO • NATIONAL TUBE DIVISION, PITTSBURGH
TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA.
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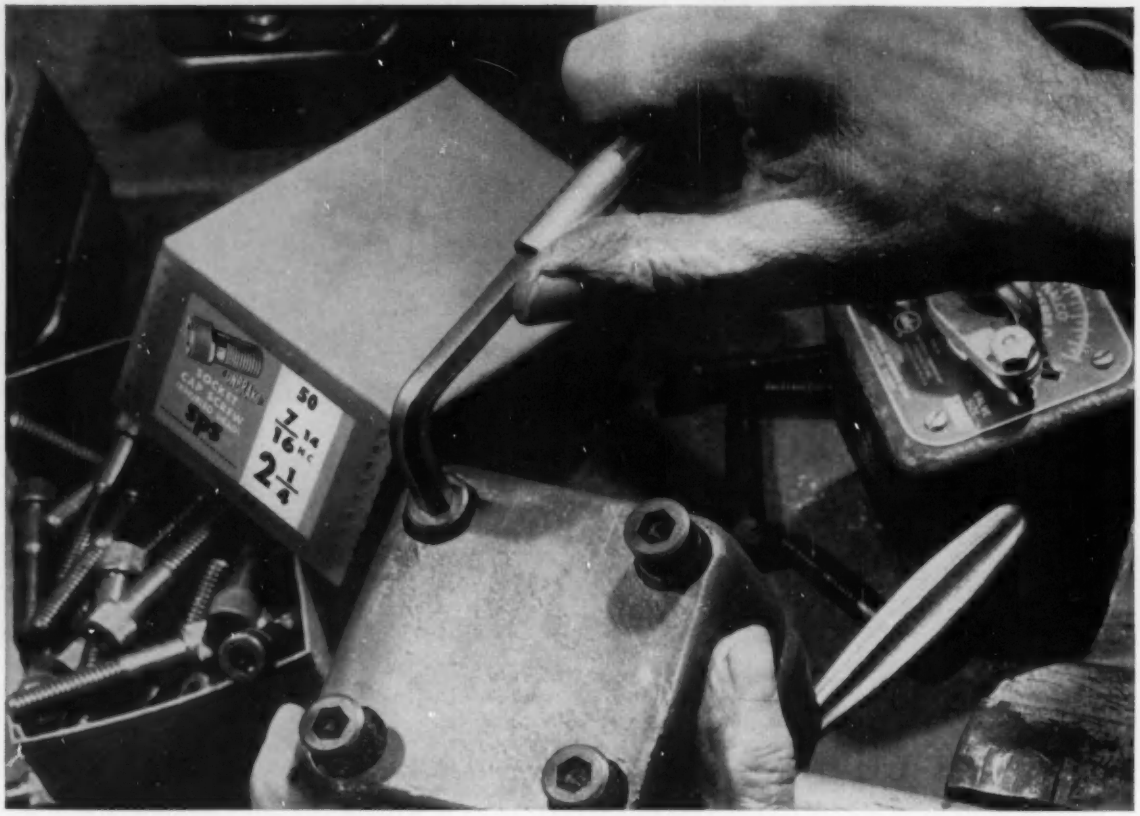
USS STAINLESS STEEL

SHEETS · STRIP · PLATES · BARS · BILLETS
PIPE · TUBES · WIRE · SPECIAL SECTIONS

USS

UNITED STATES STEEL



Tighten socket screws tighter, more safely with High-Titan UNBRAKO hex keys

High-Titan UNBRAKO socket screw keys are stronger than ordinary keys. They are made of selected, accurately sized hex stock, with carefully formed 90° bends that won't break. The ends are cut square to engage sockets full depth for highest tightening power. These keys are heat treated uniformly to give hardness and ductility clear through without brittleness or decarburization.

All this results in many advantages. You can torque up a screw tighter with an UNBRAKO than any other key. Performance is consistent—you can apply the same tightening torque every time. Screw sockets won't ream, and the keys won't wear excessively. If you should apply too much torque, a High-Titan would break, but shear off clean and even with the top of the socket—not at the bend—and without leaving jagged exposed edges to gash your hands.

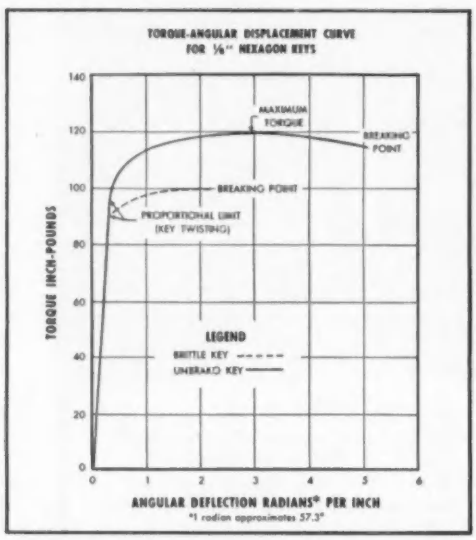
One High-Titan hex key is included with each standard package of UNBRAKO socket screws. High-Titans are also available as sets in convenient, durable plastic key folds, and in bulk. Your authorized industrial distributor carries them in stock. See him today. Unbrako Socket Screw Division, STANDARD PRESSED STEEL CO., Jenkintown 28, Pa.

See us at the Design Engineering Show
Booth 333-335

STANDARD PRESSED STEEL CO.

UNBRAKO® SOCKET SCREW DIVISION

SPS
JENKINTOWN PENNSYLVANIA



THESE CURVES SHOW THE DIFFERENCE between an UNBRAKO hex key and an ordinary key. The UNBRAKO withstands more tightening torque, twists through 180° without breaking, then shears off even with the top of the screw socket. Ordinary keys snap off suddenly at the bend.

The Best

Standardized gearing in stock . . .

are the easiest

housing sub-assemblies in stock . . .

to get

and standardized pinions in stock . . .

mean faster deliveries from stock!

FOOTE BROS.
LINE-O-POWER SPEED REDUCERS

Standardized interchangeable gearing – by Foote Bros. – lets you specify and get the particular reducer you want, in the quantities you need, direct from stock! Duti-Rated Lifetime Gearing in a complete range of interchangeable sizes, ratios and capacities are stocked and ready for assembly. Capacities range up to 200 H. P., ratios to over 2700 to 1. Standard foot and flange type cast housings are stocked, too, for straight or right angle drives. The drives you want are assembled from stock components and shipped as soon as your order is received. For a complete index to the almost endless variety of Line-O-Power reducers immediately available, write for your copy of the Line-O-Power catalog today. See for yourself how you can get more for your drive dollar . . . faster!

This trademark stands for the finest industrial gearing made!

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FOOTE BROS.

Better Power Transmission Through Better Gears

FOOTE BROS. GEAR AND MACHINE CORPORATION

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No dezincification after Ni-Vee bronze parts replaced manganese bronze stems in water system valves such as these produced by water works equipment manufacturer, Rich Mfg. Co., Los Angeles, Calif.

How Ni-Vee bronze valve stems halt failures in water system

VALVE STEM BREAKAGE puzzled and plagued water system engineers in the City of Los Angeles.

Cause of the trouble? Dezincification. A form of corrosion that sapped strength from manganese bronze stems in cast iron valve bodies.

Finally city engineers found the answer. As a result of 5-year tests of copper-base alloys in a variety of waters, these engineers turned to valve parts cast in Ni-Vee* nickel-tin bronze.

High mechanicals

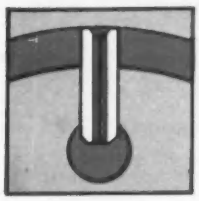
Containing less than 2% zinc, mainly for scavenging in the melt, Ni-Vee bronze stays immune to dezincification. Thus, it retains its original strength indefinitely. But that's only part of the story.

Ni-Vee bronze gives you high "as cast" tensile strength which simple heat treatment can lift up to 90,000 psi. In addition, this bronze resists wear, impact and galling. It offers easy castability, low shrinkage, pressure tightness, fine grain. Versatility plus economy.

Avail yourself of the money-saving advantages afforded by this simple family of five outstanding Ni-Vee bronzes. Use them anywhere copper-base cast alloys have application for pressure, constructional and bearing needs. And write for your copy of *"Engineering properties and applications of NI-VEE BRONZES."* Do it now. *Registered trademark

INCO TRADE MARK

THE INTERNATIONAL NICKEL COMPANY, INC. 67 Wall Street New York 5, N. Y.



TWO VANES ARE BETTER THAN ONE

The hydraulically counterbalanced DUAL-VANES in DUDCO Hydraulic Pumps eliminate wear producing loads normally caused by unbalanced hydraulic forces and vane acceleration. DUAL-VANES also maintain MULTIPLE SEALING BARRIERS to slippage and power loss. DUAL-VANES are a patented and exclusive DUDCO feature.

Member NFPA

NFPA NATIONAL FLUID POWER ASSOCIATION

CONTROLLED FLUID POWER Gives Your Machine Tools Greater *Flexibility*...

DUDCO PF-100 Series Double Pumps with combination relief and unloading valves provide high circuit flexibility through either automatic or external pilot control. For example... in a "hi-lo" circuit, large volume delivery is available for a fast traverse cycle. Then, during the feed cycle, when small volume is required, one pump section unloads automatically... saving dollars in horsepower! These pumps can also be operated on separate circuits . . . each circuit protected by its own relief valve.

DUDCO Pumps can operate *continuously* at 2000 psi. Their exclusive "Dual-Vane" feature and advanced design combine to assure long trouble-free performance and maximum simplicity in servicing. Thus, they are a natural choice for a wide variety of high production equipment, including: Machine Tools, Hydraulic Presses, Die Casting and Plastic Moulding Machines, Closing and Clamping Devices and other functions calling for controlled variation in Pump volume.

The PLUS factors in DUDCO Pumps weigh heavily at the sales end—so, WRITE... get the facts on DUDCO Dual-Vane Hydraulic Pumps and Fluid Motors.

KALAMAZOO DIVISION
THE NEW YORK AIR BRAKE COMPANY
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INTERNATIONAL SALES OFFICE, 90 WEST ST., NEW YORK 6, N. Y.

SPECIAL MACHINERY BUILDERS FIND HYDRAULICS SPECIALISTS VALUABLE ALLIES

Independent Engineering Firms Assist With Custom Designs

A large part of the production equipment used in industry is specially built machinery or machine tools tailored to individual needs. Unlike stock equipment, these units are "one of a kind," built to perform specific functions. And, because such machines are not standard in any sense, the problems of securing components and making them work are important.

Fortunately for industry, there are today well established companies fully competent to assist with the design and engineering of the hydraulic circuits of such machines. They are also ready to supply and service the hydraulic components so vital to these machines. These distributors of Fluid Power equipment stock, sell, engineer and service every component for even the most complicated Fluid Power circuit. They can furnish anything from a single hose coupling to a complete Fluid Power application and make the installation if needed.

One well-known organization of this type is The Rucker Company of Oakland, California, with four busy branch offices on the west coast. The Rucker Company has well stocked warehouses and provides a complete engineering service for its customers in every type of industry.

Another important organization servicing the Detroit area is the J. N. Fauver Company. It carries in stock just about every type of hydraulic component that a machine builder could use. It can furnish engineering assistance to almost any extent, too.

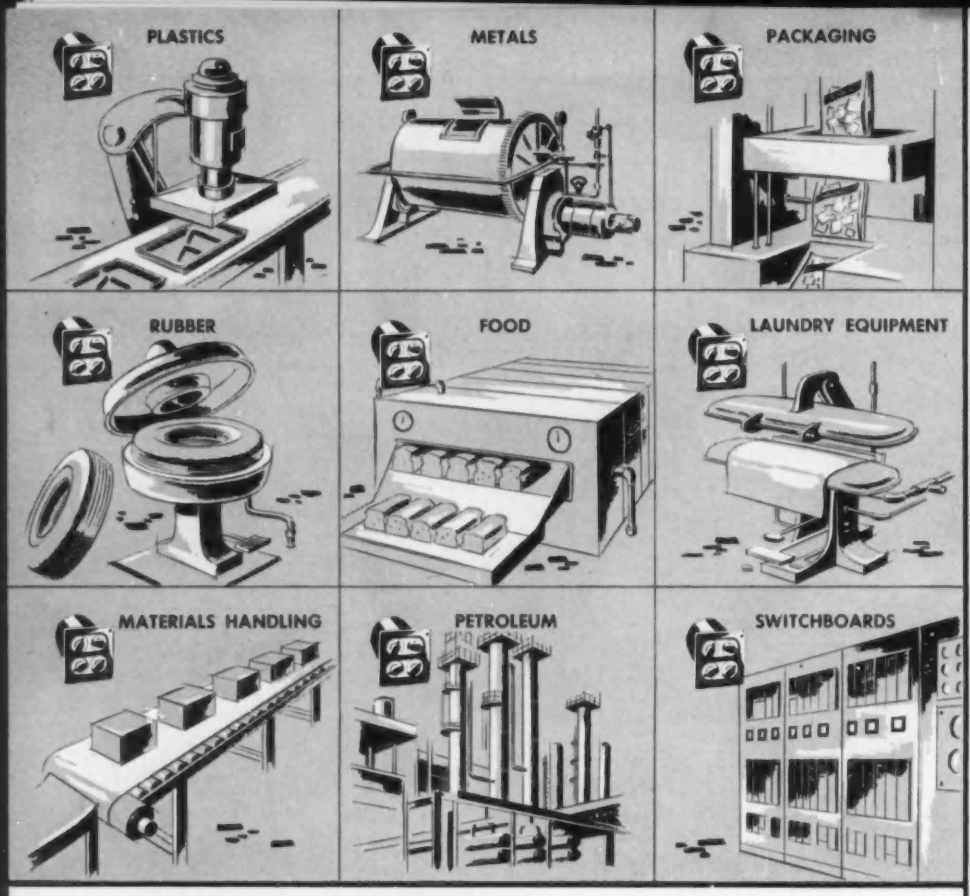
Both of these companies stock a complete line of HYDRECO and DUDCO Fluid Power equipment.

They have no affiliation with the manufacturers of the products they sell. They are owned and operated by independent businessmen who understand the problems of the independent businesses they serve.

KALAMAZOO Division
The New York Air Brake Company
9012-5 E. Michigan
Kalamazoo, Michigan

Gentlemen:
I would like more information about the DUDCO PF-100 Series Double Pumps with Valve Panels. Please send me Bulletin DP-308.

Name_____
Company_____
Address_____
City_____ Zone_____ State_____



In All These Applications . . .

3 NEW FEATURES OF G-E INTERVAL TIMER IMPROVE CONTROL AND CUT TIMING COSTS

To give you even greater versatility in time control, the General Electric TSA-18 interval timer may now be equipped with these optional features: new reset contacts, elapsed time indication and a program retaining mechanism.

NEW RESET CONTACTS make possible *either* automatic resetting or automatic recycling in the same timer. A simple change in external wiring is all that is necessary to change from one to the other. With *automatic resetting* you can eliminate manual resetting or mortgaging another circuit to achieve the reset action. With *automatic recycling*, the timer will reset at the end of a time cycle and immediately start the next cycle. This gives you a continuous repeating time-cycle program.

ELAPSED-TIME INDICATION, shown by a small dial on the timer face, gives you a continuous, accurate reading of time elapsed from the start of your time-cycle program—especially useful on long programs.

PROGRAM RETAINING: In case of power failure the program-retaining mechanism will hold the timer at the point of interruption and restart it at this point when power is restored. (Cannot be used in the same timer with reset contacts.)

MANY STANDARD "EXTRAS" are included in the TSA-18 timer: delayed on-and-off timing in intervals from 1 second to 30 hours; knob-locking device to prevent missetting; high setting accuracy of 1%; high repeat accuracy of ¼%; dust-proof case—*all standard at no extra cost.*

YOUR COSTS ARE REDUCED because the TSA-18 interval timer will increase the equipment operators can handle and free them for more productive activity. Waste or spoilage of materials can also be reduced, with the higher degree of uniformity that G-E timed control gives you.

For further information, contact your nearest General Electric Apparatus Sales Office, or write for bulletin GEC-1223 to Section 584-3, General Electric Company, Schenectady 5, N. Y.

Progress Is Our Most Important Product

GENERAL ELECTRIC

G-E TSA-18 TIMER WILL REDUCE COSTS IN ALL THESE OPERATIONS

IN PLASTICS

Automatic molding
Scheduled mixing of materials
Batch weighing

IN METALS

Heat treating
Flame hardening
Induction heater annealing
Quenching cycles
Firing of regenerative furnaces
Plating
Bath and soak cycles
Motor reversing cycles—tumbling
Batch weighing
Sequencial adding of materials

IN FOOD PROCESSING

Sugar centrifuge control
Dough mixing
Dehydration equipment
Automatic chicken pickers
Roasting processes
Motor reversing cycles—agitators
Adding ingredients in sequence
Infra-red oven control
Molding and pressing
Batch weighing
Bag folders
Heat sealers—plastic bags
Bag and box fillers

IN MACHINE TOOLS

Flame hardening
Heat treating
Resurfacing of grinding wheels
Final polishing intervals
Periodic lubrication

IN RUBBER

Tire and tube curing cycles
Injection period control

IN CHEMICALS

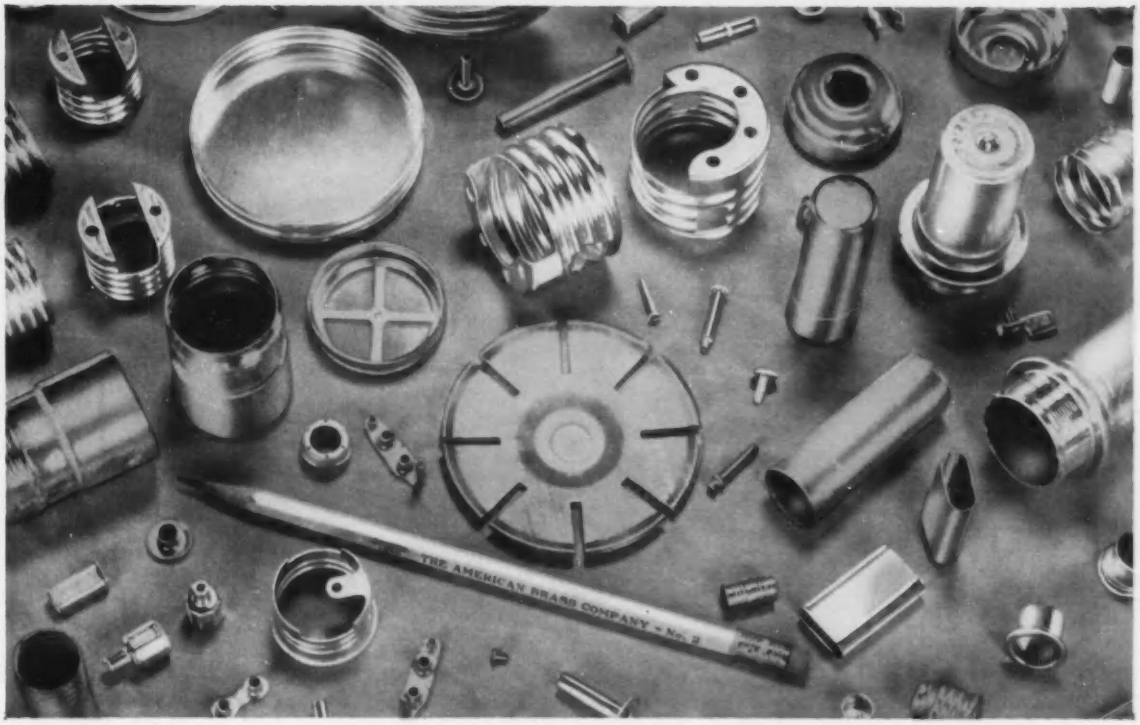
Motor reversing cycles—agitators
Atomic radiation control—setting exposure reading interval
Batch weighing
Sequencial adding of materials
Testing photographic emulsions
Infra-red oven control
Purging of filtration tanks
Dehydration equipment

IN CONTROL PANELS

Single time-interval operation
Multiple time-interval operation
Recycling of timed operations
Sequencial cycling of automatic machines
Motor-reversing cycles
Reclosing of circuit breakers
Unattended substation starting

AND MANY OTHERS

Transit-system scheduling
Glass polishing cycles
Spin and surge protection of deep well pumps
Automatic paint spraying devices
Photo copying equipment
Automatic door closing
Dry cleaning and laundry machines
Alarm initiation
Dust collectors and shakers
Quality control
Materials handling
Periodic test sampling



Why should you use valuable floor space to make parts like these?

FERRULES
for desk and chair legs, pipes, tool handles, cutlery handles and pencils, etc.

EYELETS
for all types of industrial fastening applications

GROMMETS AND WASHERS
standard sizes in stock for canvas and fabric hardware and other uses

STAMPED PARTS
of every description, including washers of heavy or light metal

SCREW SHELLS
for lamps, tubes, all electrical applications

DEEP DRAWN PARTS
cups and shells of all types, finished or unfinished

The American Brass Company has specialized equipment, such as high-speed multiple-plunger presses, for the economical production of parts like these for industry. It has thousands of stock tools which may save tooling-up charges—tools and techniques developed over a century of service to manufacturers.

Your choice of metal: Parts like these can be furnished in copper, brass, bronze, nickel silver, nickel, iron, stainless steel, steel, and aluminum – in a wide variety of finishes.

Standard products: For a selection of more than 1000 eyelets of common sizes and styles, as well as eyelets kept in stock, write for Catalog BG-1.

Special products: Just send a sample, drawing, or description, together with quantity and other pertinent information. Address: The American Brass Company, Waterbury Brass Goods Division, Waterbury 20, Conn. 5068

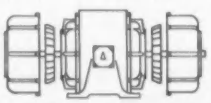
ANACONDA® MULTIPLE-PLUNGER PRESS PRODUCTS

Both bearings get cool air in new DELCO Electric Motors!

Better cooling increases bearing life and reduces maintenance on heavy-duty TEFC units

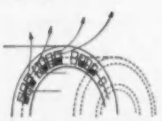
Two fans, each strategically located near one of the bearings, give these large totally-enclosed, fan-cooled Delco Electric motors a more effective cooling system. The bearings get the coolest air first. Then, the entire motor is evenly cooled as the air moves rapidly through special tunnels built in the wall of the main frame. This remarkable new system assures quiet air flow, increased bearing life and less need for maintenance. It's another example of how Delco Products engineering leads the way in solving your motor problems to provide more value, more consistently good performance on every application. Contact your nearby Delco Products distributor or sales office now for *all* your motor requirements.

HERE'S HOW IT WORKS!



Cool air enters at both ends, cools bearings, tunnels across entire motor.

Tapered fans turn cool air inward, scrub heat off vital bearing sites.



Quiet air movement is controlled by large tunnels in motor frame.

GM GENERAL MOTORS DELCO DAYTON OHIO

DELCO *Electric* MOTORS

DELCO PRODUCTS, DIVISION OF GENERAL MOTORS, DAYTON, OHIO

Proved best by Performance!

Valve designers and engineers . . . it will pay you to specify

R/M "CUSTOM-MADE" VALVE STEM PACKINGS

Regardless of the service requirements of that valve you're working on, there's an R/M Valve Stem Packing that will solve your sealing problem. Water, steam, gases, petroleum derivatives, and caustics all can be handled, even under the most adverse pressure and temperature conditions.

R/M die-formed Valve Stem Packings can be supplied in two general types: braided (asbestos yarns) and fibrous (plastic). The only limitation on shape is the type of construction desired. A wide variety of binders and lubricants can be furnished to meet individual requirements.

In addition to the die-formed types described, R/M can provide die-cut and lathe-cut rings from many types of rubber and synthetic rubber, with or without fabric reinforcement.

One of the pioneers in the packing industry, R/M offers complete cooperation in the development of a packing to fit your individual requirements.

For complete information, send for brochure on Custom-Made Valve Stem Packings

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RAYBESTOS-MANHATTAN, INC.
PACKING DIVISION, PASSAIC, N.J.
MECHANICAL PACKINGS AND GASKET MATERIALS

FACTORIES: Bridgeport, Conn.; Manheim, Pa.; Neenah, Wis.; No. Charleston, S. C.; Crawfordsville, Ind.; Peterborough, Ontario, Canada

RAYBESTOS-MANHATTAN, INC., Packings • Asbestos Textiles • Industrial Rubber, Engineered Plastic, and Sintered Metal Products • Abrasive and Diamond Wheels • Rubber Covered Equipment • Brake Linings • Brake Blocks • Clutch Facings • Laundry Pads and Covers • Bowling Balls

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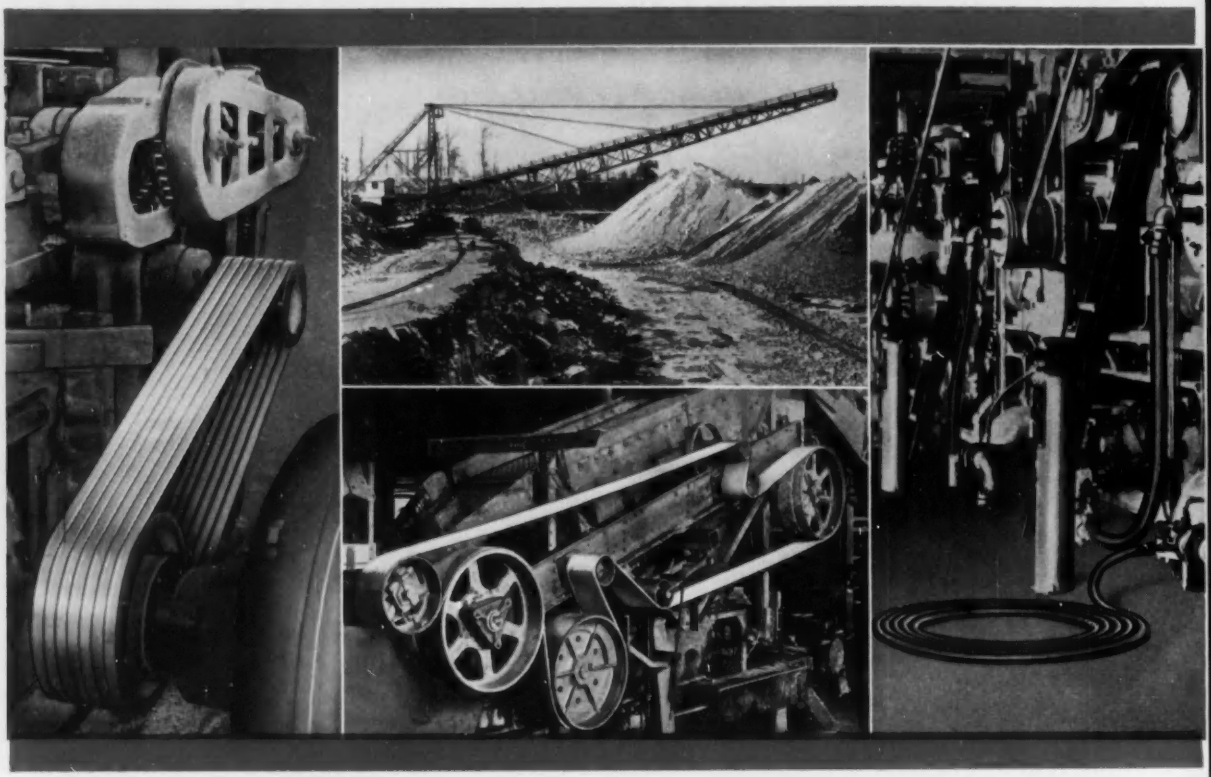


R/M RUBBER PRODUCTS FOR BETTER PERFORMANCE, LOWER COST

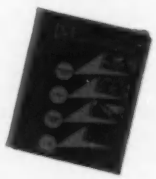
Advanced engineering backed by over 60 years manufacturing experience serves the design engineer who depends on R/M mechanical rubber products. A complete line of R/M engineered conveyor belts, for example, includes Ray-Man Conveyor Belt with *extra* flexibility, *extra* tear resistance for heavy duty applications where thick, narrow belts and small pulleys are required. Other constructions are specially designed for portable and package conveyors. If you use hose, R/M has light Homoflex Hose with rope-like flexibility for air tools and water; all-purpose constructions like new Allflex for air, water, oil, gases and mild chemicals. Special burst-resisting types with wire insertion can be made for high pressure to handle steam and air safely. Whatever your requirements, let R/M work with you.

Condor and R/M Super-Power V-Belts are made with straight sidewalls to assure better tensioning and grip, less slip and longer life. Users call them "the smoothest running V-belts made." Where flat belt drives are used, R/M offers a complete selection of belts and driving surfaces from low tension to desired slip for every requirement. Most revolutionary is the new space-saving R/M Poly-V® Drive that combines the positive tracking and V grip of V-belts with the strength and simplicity of flat belts in a *single* endless belt drive. It delivers up to 50% more power in the same space as multiple-belt drives or equal power in ⅔ the space—with no multiple-belt matching problems!

R/M also designs and mass produces engineered molded parts of natural and synthetic rubber or silicone in any size or shape to meet your specifications.

For booklet shown, or other data, write, phone or wire:

MANHATTAN RUBBER DIVISION
Raybestos-Manhattan, Inc.
Passaic, N.J.
GRegory 3-2000



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Industrial Drive Belts

Industrial and Automotive Hose

FOR HELP IN SOLVING YOUR PROBLEMS

PACKINGS, GASKETS ASBESTOS TEXTILES and "TEFLON"* PRODUCTS

If you are designing or making equipment that must operate under the most adverse conditions, R/M "Teflon" packings and gaskets may be the answer to your sealing problem. They have proved to be impervious to all known industrial acids, caustics and solvents; have zero water absorption; and show excellent resistance to weathering.

The complete R/M "Teflon" line includes mechanical packings and gaskets, sheets, rods and tubes, thin-wall tubing, tape, and special shapes made to order. "Teflon"-impregnated asbestos sheets and packings are also available. Don't hesitate to call on R/M for answers to your particular problems.

*Du Pont Trademark

For booklet shown, or other data, write, phone or wire.

PACKING DIVISION
Raybestos-Manhattan, Inc.
Passaic, N.J. • GRegory 3-2000

ASBESTOS TEXTILE DIVISION
Raybestos-Manhattan, Inc.
Manheim, Pa. • Manheim 5-2211

PRECISION MOLDED PRODUCTS

Precision molding is a mass-production method developed by R/M for economically manufacturing asbestos, with binders and fillers, into finished parts for structural and friction applications to accurate dimensions. Depending on quantity, size and shape, precision molded parts not only cost less, because machining is reduced or eliminated, but also frequently give better performance as well. Unlike other manufacturers, R/M works with all kinds of friction materials. So that whether you need precision molded products or some other type part, you can be sure of unbiased advice when you bring your problem to R/M.

New R/M Bulletin No. 550 contains complete design and engineering data on precision molded products. Write for your copy. For technical information on all other R/M friction materials, ask for Bulletin No. 500.

EQUIPMENT SALES DIVISION
Raybestos-Manhattan, Inc.
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RAYBESTOS-MANHATTAN, INC.

FACTORIES: Passaic, N.J. • Bridgeport, Conn. • Manheim, Pa. • No. Charleston, S.C. • Crawfordsville, Ind. • Neenah, Wis. • Peterborough, Ontario, Canada

Conveyor Belts

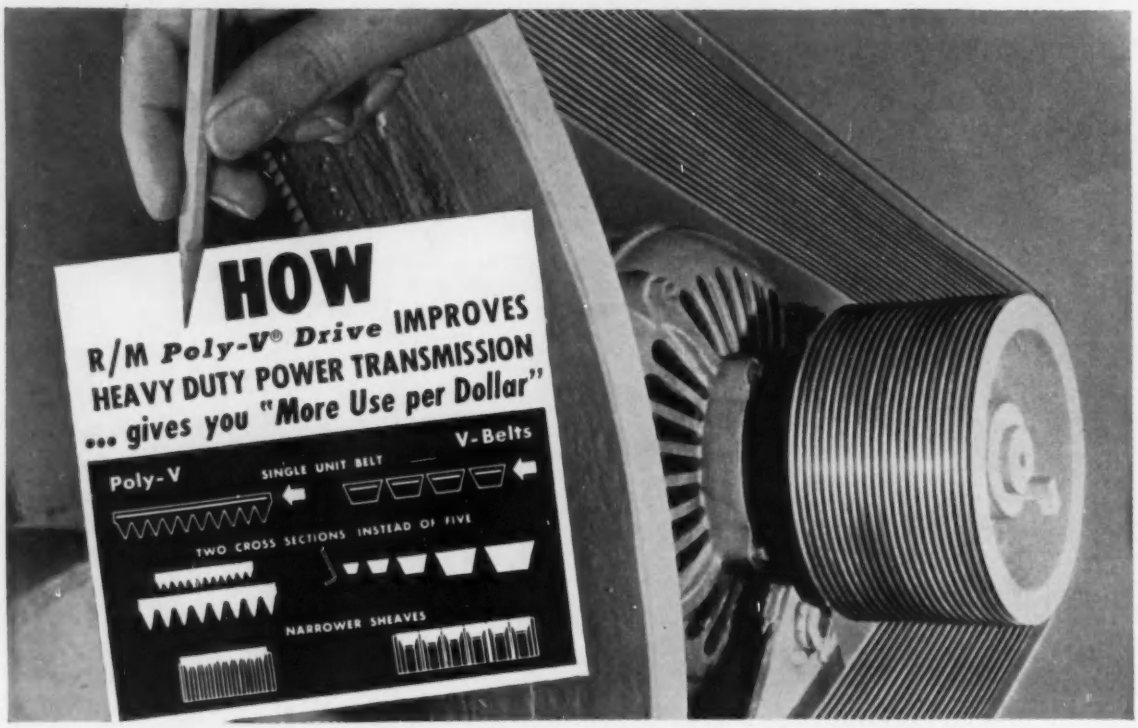
Rubber Lined and Covered Equipment

Sintered Metal Friction Elements

Asbestos Textiles

Teflon Tape, Packings, Sheets, Rods, Tubes

Engineered Molded Rubber and Plastics



Designers call R/M *Poly-V*® the "ideal" belt drive

Here it is . . . Raybestos-Manhattan's answer to design engineers' demand for a superior belt drive to simplify heavy duty power transmission. It's the patented R/M Poly-V Drive . . . the only completely new concept in power transmission which combines the strength and simplicity of flat belts and the high V grip and positive groove tracking of V-belts!

Why has it proved the "ideal" drive for a great variety of applications?

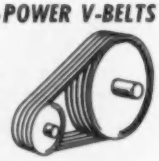
It saves space. R/M Poly-V Drive employs a single, endless, parallel V-ribbed belt running on sheaves designed to mate precisely with the belt ribs. Because this single unit belt has a much higher horsepower capacity per square inch than ordinary V-belts, drive sheaves are narrower. You get up to 50% *more* power delivery in the same space as a standard multiple V-belt drive, or *equal* power in as little as 2/3 the space . . . with *less* shaft overhang and *less* drive weight.

Poly-V Drive maintains constant pitch diameter at all loads. No more sinking of belts in the sheave grooves: Poly-V belt speed ratio and belt position remain more constant from no load to full load to run smoother, cooler, with less wear on belt and sheaves. Just two cross sections of Poly-V Belt meet every heavy-duty power transmission requirement, as compared to five with V-belts. R/M Poly-V Drive cuts costly belt and sheave inventories to a new low!

R/M engineers who developed Poly-V Drive will be glad to give you further data on these and other advantages of this amazing new drive . . . and to work with you to determine the installation that will mean "More Use per Dollar" for your application. Contact an R/M representative . . . or write for a copy of Poly-V Drive Bulletin #6638.

CONDOR V-BELTS • R/M SUPER-POWER V-BELTS

Write for Bulletin #6868 on the complete line of Condor V-Belts for regular service on conventional V-belt drives. Also write for Bulletin #6628 on R/M Super-Power V-Belts with 40% more Horsepower capacity where needed.



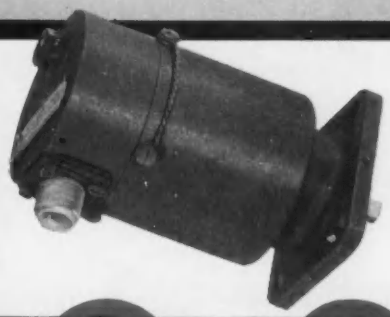
*Poly-V is a registered Raybestos-Manhattan Trademark RM-628

MANHATTAN RUBBER DIVISION—PASSAIC, NEW JERSEY

RAYBESTOS-MANHATTAN, INC.

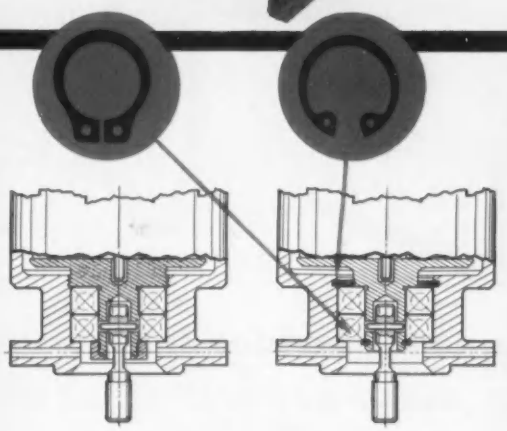
Other R/M products include: Industrial Rubber • Fan Belts • Radiator Hose • Brake Linings • Brake Blocks • Clutch Facings • Asbestos Textiles • Packings • Engineered Plastic, and Sintered Metal Products • Laundry Pads and Covers • Bowling Balls

10 Waldes Truarc rings speed assembly– Eliminate parts and machining in precision control



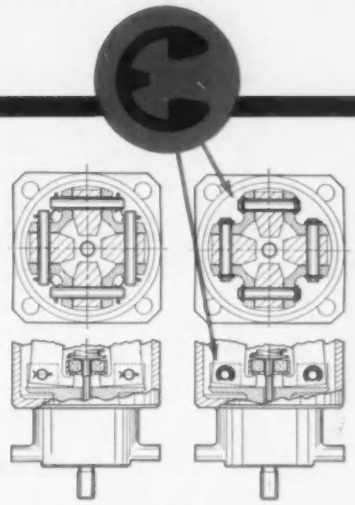
Kahn Rotary Speed Control

Kahn and Company, Inc., of Hartford, Conn., use a total of 10 Waldes Truarc Retaining Rings in this new mechanical-electric translator for automatic control of rotary speed. Truarc rings act as positioners and retainers to eliminate parts, simplify operations, save labor, and speed assembly.



Rotor Installation. In the old way, ball bearing was retained by a threaded shoulder and threaded bearing cup retainer.

New way, using two Truarc Rings (Series 5100 and 5000) eliminates 4 threading operations, bearing shoulder and threaded bearing cup. Assembly is quicker and easier, two ounces lighter.



Flyweight Assembly. Formerly, 2 holes had to be drilled in each of the 4 pivots, and 8 cotter pins were required.

The new way, using 8 Truarc E-Rings (Series 5133), replaces holes with grooves, reduces pivot size, leaves no projecting parts. Rings snap into place, speed assembly time by three minutes per unit.

Whatever you make, there's a Waldes Truarc Retaining Ring designed to improve your product... to save you material, machining and labor costs. They're quick and easy to assemble and disassemble, and they do a better job of holding parts together. Truarc rings are precision engineered and precision made, quality controlled from raw material to finished ring.

36 functionally different types... as many as 97 different sizes within a type... 5 metal specifications and 14 different finishes. Truarc rings are available from 90 stocking points throughout the U. S. A. and Canada.

More than 30 engineering-minded factory representatives and 700 field men are available to you on call. Send us your blueprints today... let our Truarc engineers help you solve design, assembly and production problems... without obligation.

For precision internal grooving and undercutting ... Waldes Truarc Grooving Tool!

WALDES TRUARC® RETAINING RINGS

Send for new catalog supplement

Waldes Kohinoor, Inc., 47-16 Austel Place, L. I. C. 1, N. Y.

Please send the new supplement No. 1 which brings Truarc Catalog RR 9-52 up to date.

(Please print)

Name.....

Title.....

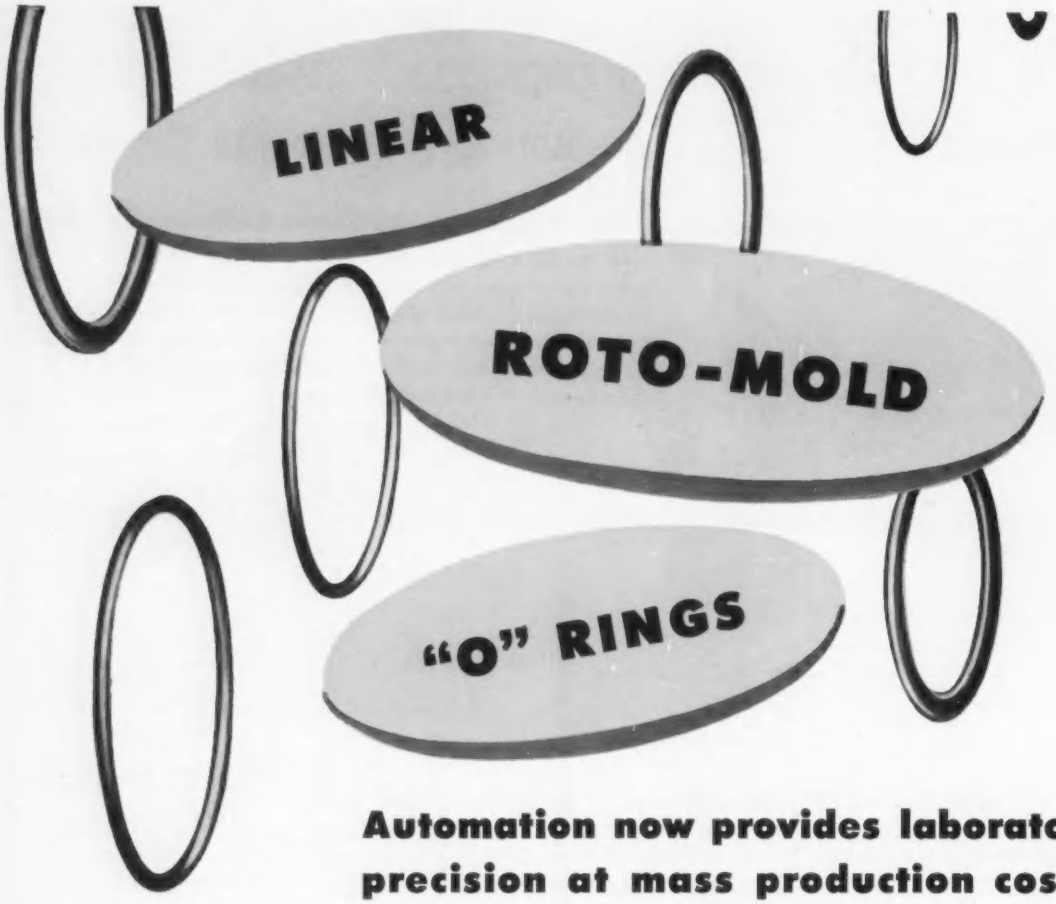
Company.....

Business Address.....

City..... *Zone*..... *State*.....

PN 058

WALDES TRUARC Retaining Rings, Grooving Tools, Pliers, Applicators and Dispensers are protected by one or more of the following U. S. Patents: 2,382,948; 2,411,426; 2,411,761; 2,416,852; 2,420,921; 2,428,341; 2,439,785; 2,441,846; 2,455,165; 2,483,379; 2,483,380; 2,483,383; 2,487,802; 2,487,803; 2,491,306; 2,491,310; 2,509,081; 2,544,631; 2,546,616; 2,547,263; 2,558,704; 2,574,034; 2,577,319; 2,595,787. and other U. S. Patents pending. Equal patent protection established in foreign countries.



Automation now provides laboratory precision at mass production costs!

LINEAR'S exclusive ROTO-MOLD process has introduced *automation* to the packing industry: Perfectly uniform "O" Rings can now be delivered quickly—in any quantity! Here are the facts:

- LINEAR ROTO-MOLD "O" Rings are made with laboratory precision in single cavity molds under individually controlled pressure. Molding dies are automatically brought into microscopic alignment.
- Every ROTO-MOLD "O" Ring is perfectly circular in cross section, with no transverse or other seams. You get precise uniformity without trimming or grinding.
- The ROTO-MOLD process is fully automatic. Contamination or imperfections due to human error are eliminated.

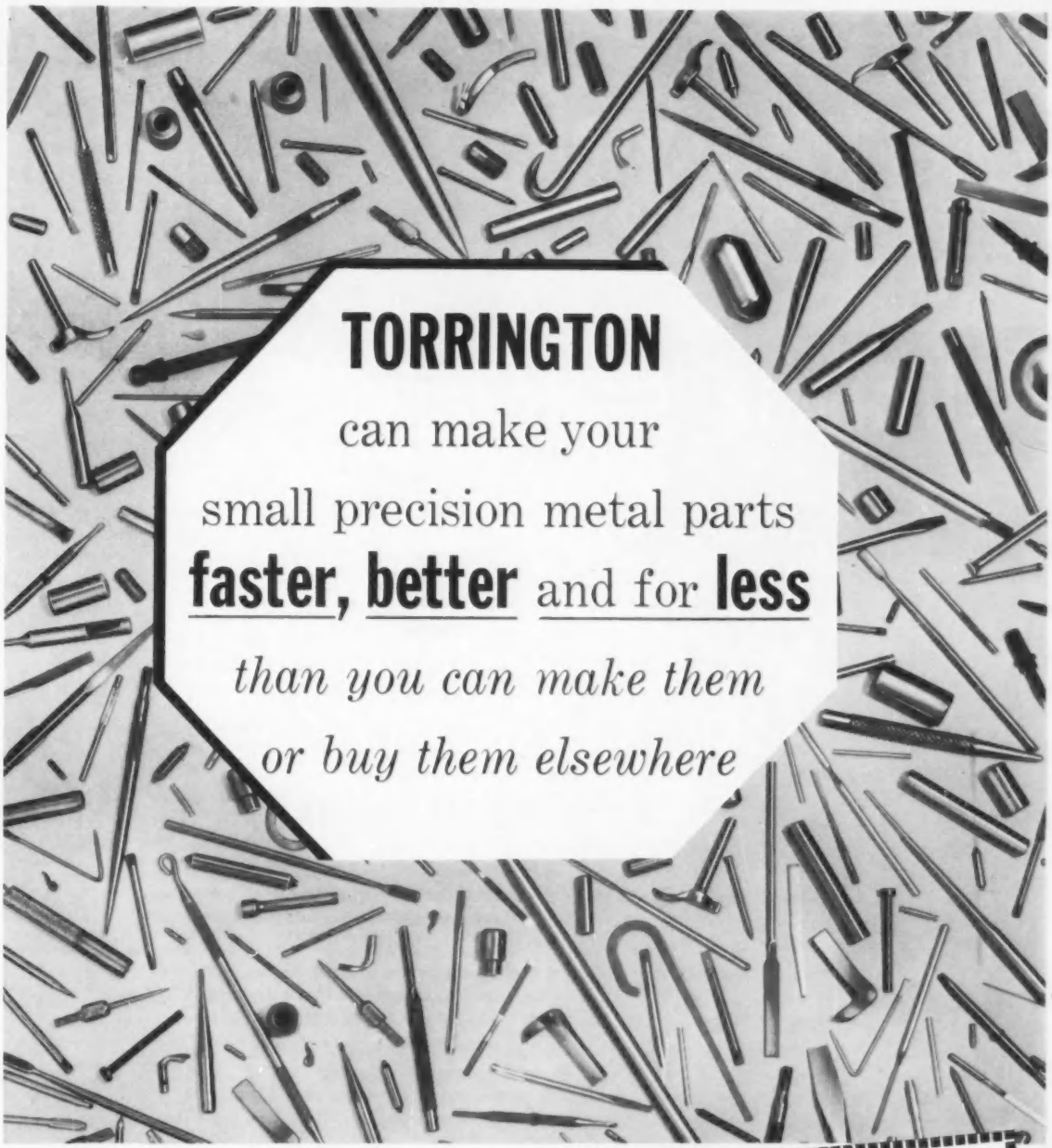
LINEAR ROTO-MOLD "O" Rings are available now, in a variety of sizes and compounds—including the latest polymers developed to resist destructive fluids at elevated temperatures. Write, phone or wire for complete details.

While in Philadelphia for the **DESIGN ENGINEERING SHOW** call on us with your sealing problems

"PERFECTLY ENGINEERED PACKINGS"

LINEAR

LINEAR Inc., State Rd. & Levick St., Philadelphia 35, Pa.



These are typical of parts that Torrington produces daily by the hundreds or millions. If you use similar small precision parts, mail the coupon today for the Torrington Small Precision Parts condensed catalog. Even better, send a sketch, blueprint or sample part. We will give you a prompt quotation which will mean substantial savings to you.

90th ANNIVERSARY 1866-1956

THE TORRINGTON COMPANY
Specialties Division
230 Field Street, Torrington, Conn.

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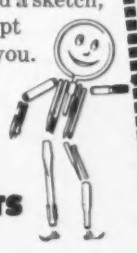
Makers of Torrington Needle Bearings



THE TORRINGTON COMPANY
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230 Field Street, Torrington, Conn.

☐ **Please send the Torrington Small Precision Parts condensed catalog**

☐ **Please have a salesman call**

Name_____

Title_____

Company_____

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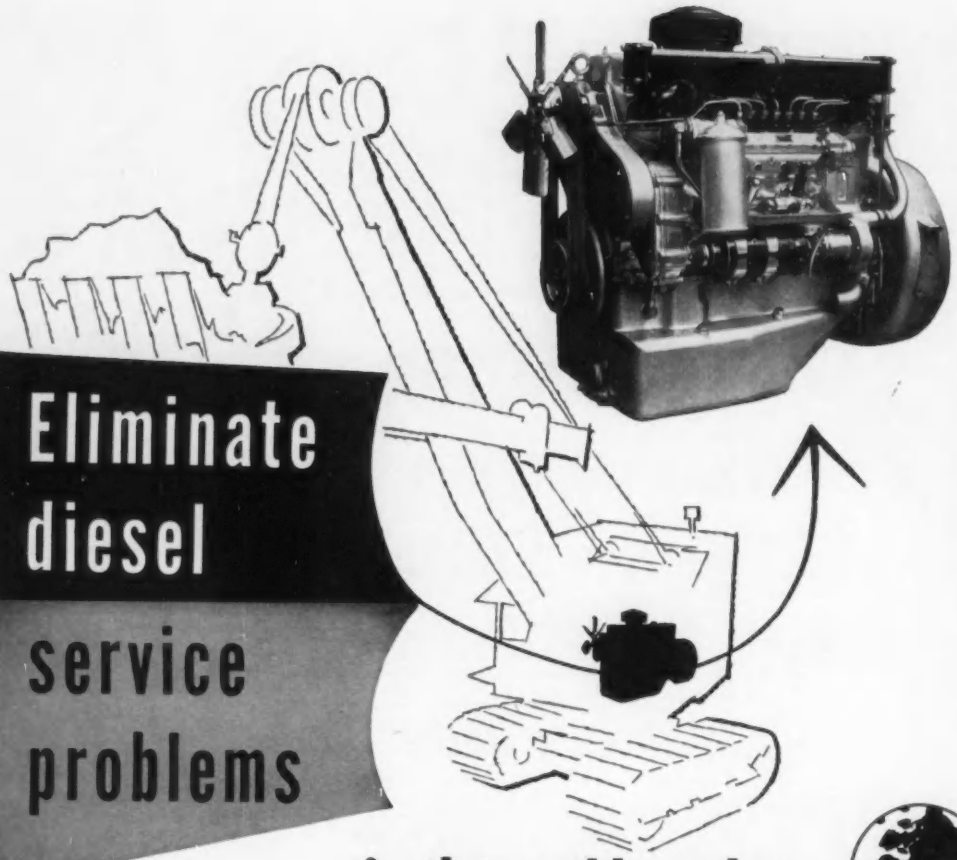
City_____ Zone____ State_____



Eliminate diesel service problems in the world market

F. PERKINS LTD. (makers of internationally famous Perkins Diesel Engines) Have Sales, Service and Parts Outlets in 106 Countries.

Perkins Diesels are in use in the following 118 countries and regions:

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You can ship heavy export units—without motors—to almost any busy spot on earth—and rely on Perkins to install and service the power for those units at destination point!

Perkins produced over 4,000,000 brake horsepower in light, high-speed diesel engines in 1954. 70% of this output went into the world markets—where Perkins Diesels set the world standard in motors up to 120 B.H.P.

These versatile engines are available to specifications of your own engineering department. And Perkins maintain an engineering staff in Toronto, Canada to work with your company. Simply phone them. They will fly down to discuss applications with you.
Prototype installations can be made at Toronto or at your plant. Deliveries can be made from Sterling sources to you or direct to your overseas branches or distributors.

Make sure of expert diesel service and availability of engine parts for all your export units . . . cut shipping costs and assembly headaches . . . call Perkins Toronto Office today.

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F. PERKINS (CANADA) LTD.
wholly owned subsidiary of
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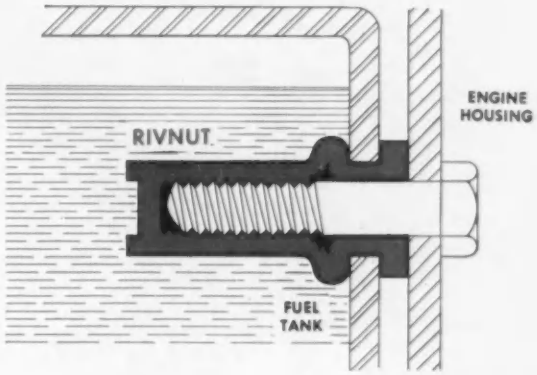
B. F. Goodrich Rivnut makes nut plate and shock-proof seal in one operation

BRIGGS & STRATTON CORP. wanted to speed the assembly and streamline the appearance of a new gasoline engine without extra cost. The conventional method of attaching fuel tanks required a combination of rivets, straps, braces, nuts and bolts. Now, by using three B. F. Goodrich Rivnuts, they do the same job quicker, neater and actually at lower cost.

One man installs the Rivnuts in the gas tank wall in seconds. They provide, firm accurate nut plates that can't be loosened by shocks or vibration. At least six threads are clean for bolt attachment to the engine housing. At the same time, special closed ends make a 100% gasoline-tight seal.

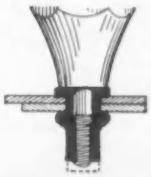
B. F. Goodrich Rivnuts are solving hundreds of fastening problems. They can probably solve yours. Write for more information or engineering help to: The B. F. Goodrich Company, Dept. PE-56, Akron, Ohio.



Rivnuts provide at least 6 clean threads in one simple operation!

1 Rivnut is threaded onto pull-up stud of a manual or pneumatic heading tool.

2 Rivnut is inserted—head firmly against work—tool at right angles to work.



3 Tool lever operates pull-up stud, forming a bulge in the Rivnut shank.

4 After upset, Rivnut threads are still clean and intact, ready for screw attachment.

Cutaway view of tank showing how Rivnuts make 100% gasoline-tight seal.

SEND NOW FOR FREE RIVNUT DEMONSTRATOR

Demonstrates with motion how you can use Rivnuts to fasten TO and fasten WITH. Explains construction, simplicity of installation. Get your free copy today by writing to: The B. F. Goodrich Company, Department PE-56, Akron, Ohio.

B.F.Goodrich

RIVNUTS

The only one-piece blind rivet with threads

For the most

NEW DEVELOPMENTS IN PACKING DESIGN BY HOUGHTON

PRE-FORMED
SHOULDER AND FLARE
MAKE CUP PACKINGS
SEAL BETTER

SPRING MOUNTED
CUPS

STANDARD STACK HEIGHT
for "V" Packings

HOMOGENEOUS RUBBER

FABRICATED RUBBER

LEATHER

advanced packing engineering

Call HOUGHTON

Houghton's newly designed leather cup packings are pre-formed. They *fit* the square corner normally found between the end of the piston and the cylinder wall.

As a result, there is no distortion of the packings under operating pressure. They are not forced into a *new* shape which would cause premature wear, fracture or breakdown at the heel. In addition, the sidewalls are molded with a slight flare which provides sufficient pre-loading for perfect sealing at minimum pressures.

VIX-SYN "O" RINGS

VIM #1243-3 CUP PACKINGS

VIX-SYN "V" PACKINGS

Provide Better Seal...Reduce Friction...Increase Life

Houghton hydraulic research has come up with one of the chief answers to the problem of excessive friction, short cup life and chatter so often encountered in cup packing installations. Now, instead of the squeezing action of tightly bolting the cup packing in place between the piston and the follower plate, you can use a low pressure spring mounting which does not deform the cup and cause early failure.

VIM "V" PACKINGS

Now we have standardized the stack height of *all* Houghton "V" packings. This means that they are interchangeable with each other in regard to stack height. Whether you use homogeneous rubber, fabricated rubber or leather "V's" . . . they'll fit! You can forget "special" dimensions, set up by various packing manufacturers for particular types of packings.

VIX-SYN "U" CUP PACKINGS

VIM "U" PACKINGS

This leadership in hydraulic know-how is typical of Houghton, which makes all types of hydraulic and pneumatic packings, as well as a complete line of hydraulic oils and fire-resistant fluids.

Standardize on Houghton. You'll get the newest first—and the best always. Call your Houghton Man and let him explain Houghton's Hydraulic Service. E. F. Houghton & Co., 303 West Lehigh Avenue, Philadelphia 33, Pa.

E. F. HOUGHTON & CO.

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Ready to give you on-the-job service . . .

There's **MORE** rating selection available in Allis-Chalmers **MOTORS**

To meet design needs...

Allis-Chalmers Offers Complete Line of Rib-Type MOTORS from 1 to 100 Hp

Allis-Chalmers, a pioneer in rib-type TEFC motor design, is the only leading manufacturer offering a complete line of these motors from 1 to 100 hp. The many cost-saving features of deep-rib construction can be applied in a variety of uses... both indoors and out.

Here's why these motors pay dividends:

MORE cooling surface — Rib-type design provides reserve cooling capacity in dirty locations.

MORE iron—Cast-iron frame and external parts assure rigidity and resistance to corrosion.

MORE copper — Allis-Chalmers greater use of copper increases electrical life.

MORE lubrication provisions — Large grease reservoirs surround bearings. Provision made for in-service relubrication — important where moisture or corrosive vapors contaminate grease.

As a new machinery component or as replacement, specify Allis-Chalmers. To find out more, contact your nearby Allis-Chalmers distributor, district office, or write Allis-Chalmers, General Products Division, Milwaukee 1, Wisconsin.

A-4941

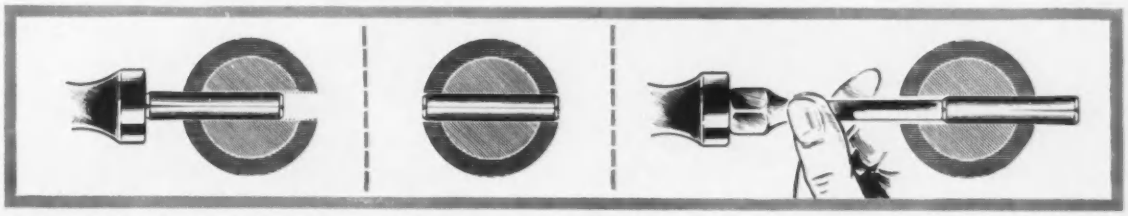
ALLIS-CHALMERS

what makes this fastener DIFFERENT?

Several things. Rollpin® is a slotted, chamfered, cylindrical spring pin which drives easily into a hole drilled to normal production standards. It locks securely in place, yet can be drifted out and reused whenever necessary. This eliminates special machining, tapping, and the need for hole reaming or precision tolerances. Rollpin replaces taper pins, straight pins and set screws; for many applications it will serve as a rivet, dowel, hinge pin, cotter pin or stop pin.

And here's another difference that makes Rollpin the quality fastener in the field: ESNA's quality control builds consistent strength and performance into every Rollpin. Rollpin is uniform as to shear strength, dimensions, hardness, and insertion and removal forces.

HOW YOU INSERT IT



Drives easily by hammer, arbor press, or air cylinder and can be readily adapted to an automatic hopper feed. Requires only a standard hole, drilled to normal production-line tolerances.

Locks securely in place without using a secondary locking device; won't loosen despite impact loading, stress reversals, or severe vibration.

Removes readily with a drift pin without damage to pin or hole, can be used again and again in original hole.

HOW YOU SAVE

You pay less for Rollpins than for most tapered, notched, grooved or dowel pins. Installation costs are substantially less than for any fastener requiring a precision fit or secondary locking operations.

Because of their tubular shape, Rollpins are lighter than solid pins. Production maintenance is reduced with Rollpins: they do not loosen and because of their spring action they tend to conform to the drilled hole in which they're inserted, without material hole wear, eliminating the necessity of re-drilling or using oversize pins.

MATERIALS AND SIZES

Standard Rollpins are made from carbon steel and Type 420 corrosion resistant steel. They're also available in beryllium copper for applications requiring exceptional resistance to corrosive attack, good electrical, anti-magnetic, and non-sparking properties. Stock sizes range from .062" to .500" in carbon and stainless steels.

ROLLPIN®

ESNA

ELASTIC STOP NUT CORPORATION OF AMERICA

Dept. R40-52, 2330 Vauxhall Road, Union, New Jersey

Please send me the following free fastening information:

- ☐ Rollpin Bulletin
- ☐ Elastic Stop nut Bulletin
- ☐ Here is a drawing of our product. What self-locking fastener would you suggest?

Name _____ Title _____

Firm _____

Street _____

City _____ Zone _____ State _____

What do Machine Builders like most about SQUARE D's New Machine Tool Relays?... SMALL SIZE!

Class 8501
Type DO-22

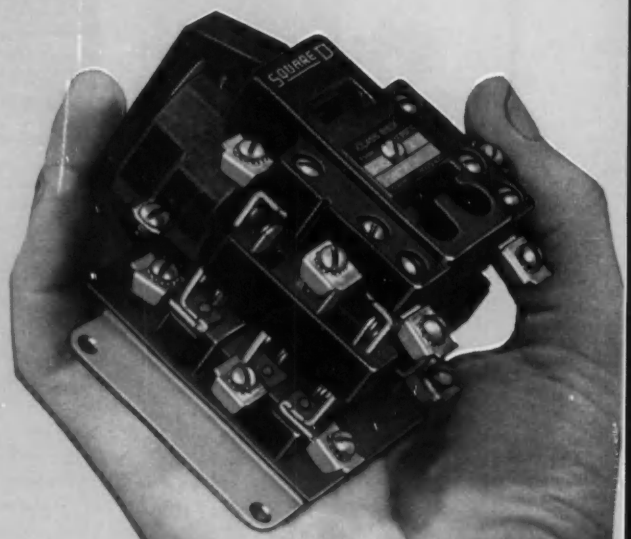
No wonder the welcome mat is out for these new 10-ampere, 600-volt relays. You've always had a warm spot in your heart for COMPACTNESS...and here it is! Let the dimensions speak for themselves—

2-pole Type DO-22 *(at left)* measures 3 5/16" high x 2 5/8" wide!

4-pole Type DO-42 *(below)* measures 3 1/16" high x 2 13/16" wide!

But that isn't all. You take these relays apart, in 20 seconds, *from the front.* No "tear down" space is needed—absolutely none!

Small size isn't the only reason machine tool builders welcome these new relays. Anything that's good for their customers is good for them—so they're not overlooking advantages like those shown on the opposite page. After all, there's something mighty satisfying about the customer's nod of approval when he sees the time-proven D nameplate on the relays that help control his new machine.



Class 8501
Type DO-42

SQUARE D COMPANY

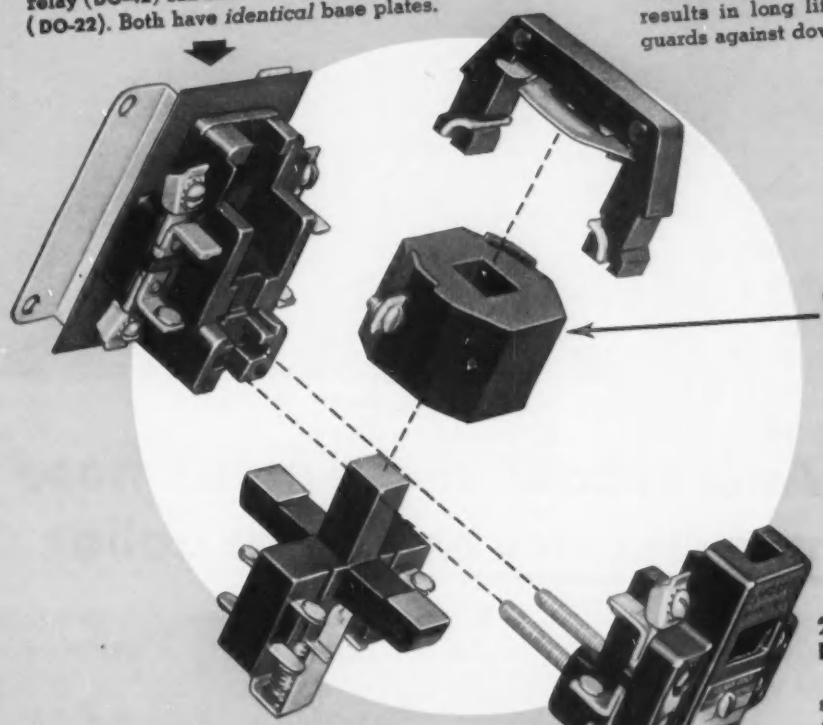
And these 4 Advantages make real sense to the men who *BUY* and *USE* the machines!

NO MOUNTING WORRIES

When more contacts are required, the 4-pole relay (DO-42) can be substituted for the 2-pole (DO-22). Both have *identical* base plates.

OUTSTANDING PERFORMANCE

Balanced construction reduces wear on single moving part . . . results in long life and safeguards against down time.



RESISTS DAMAGE

Plastic impregnated molded coil is unbreakable, operates cooler, is dimensionally stable and impenetrable by water and oil.

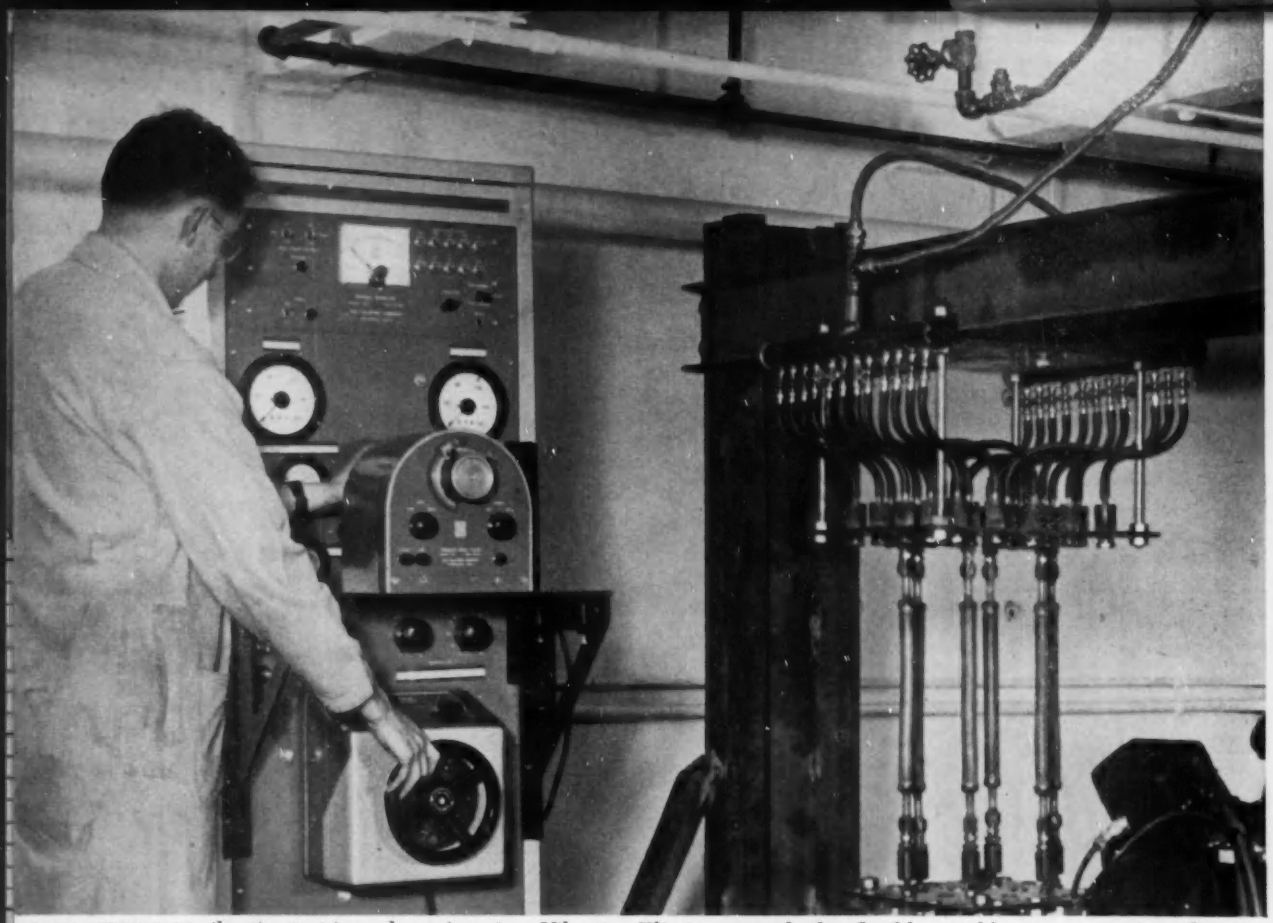
20-SECOND DISASSEMBLY

Simply loosen two screws and the entire device is disassembled for normal maintenance.

Packaged Parts Kits make normal maintenance easier than ever. Any way you look at it, these new relays are tops. Small in size—long on features and performance.

For the complete story, write for Bulletin 8501. Address Square D Company, 4041 North Richards St., Milwaukee 12, Wisconsin.

Everybody's Ahead with Square D!



HIGH FREQUENCY vibration test is made on American Vibration Eliminators and other flexible metal hose encountering vibration.

Here's why American flexible metal hose gives you more service hours per dollar

When you buy flexible metal hose, you are really buying "service." And the lowest bid is not necessarily the greatest bargain.

For customers tell us American metal hose consistently outperforms any other make . . . delivers *more service hours per dollar!* From raw material through finished assembly, American Flexible Metal Hose and Tubing undergoes continuous inspection and checking for conformance to the *highest and most rigid standards* in the industry.

FAST SERVICE

American, too, offers you fast, sure service on standard metal hose in brass, bronze, aluminum, steel and stainless steel in a wide range of sizes. End fittings are available for all types of connections. Many packaged items carried in stock.

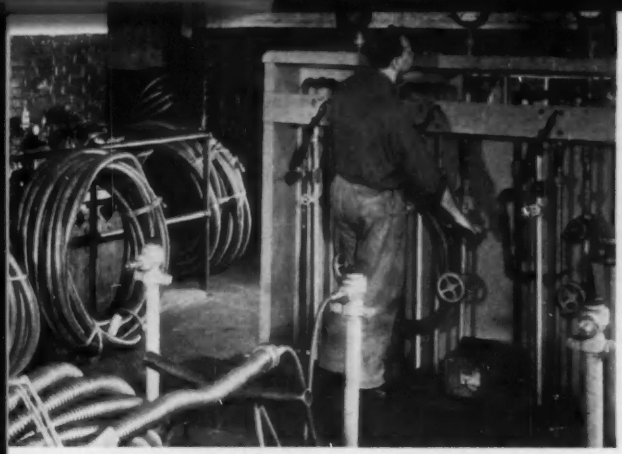
ENGINEERING ASSISTANCE

Our design service—proved on thousands of jobs—is ready to help you with your problem at no extra charge. Check with American first when you plan a new installation or want to improve unsatisfactory connections—you'll save time and money. Phone, wire or write! The American Brass Company, American Metal Hose Division, Waterbury 20, Conn. Offices in major cities. In Canada: The Canadian Fairbanks-Morse Company, Ltd.

56175

WHEREVER CONNECTORS MUST MOVE

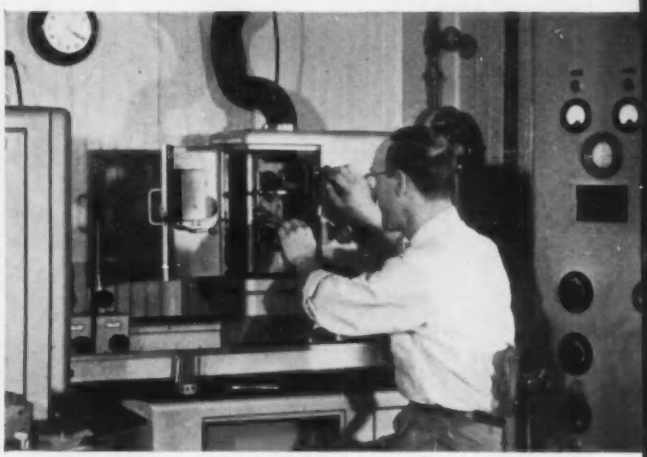
AMERICAN flexible metal hose and tubing



HYDROSTATIC, air or steam test is given all assemblies specifying pressure tightness. Test assures units absolutely free of leaks.

CONTINUOUS FLEXURE testing is conducted to be certain that the longest life is "built into" American Metal Hose Assemblies.

ON THE JOB INSPECTION at frequent intervals during fabrication assures rigid compliance with customers' specifications.



SPECTROGRAPHIC analysis to determine alloy content of metal is typical of American's program to assure that finished assemblies are "right"—from the start.

MICROSCOPIC EXAMINATION of sections of raw materials determines if such factors as grain structure meet required quality standards.

an **ANACONDA**® product

FREE CATALOG!

THE AMERICAN BRASS COMPANY
American Metal Hose Division,
Waterbury 20, Conn.

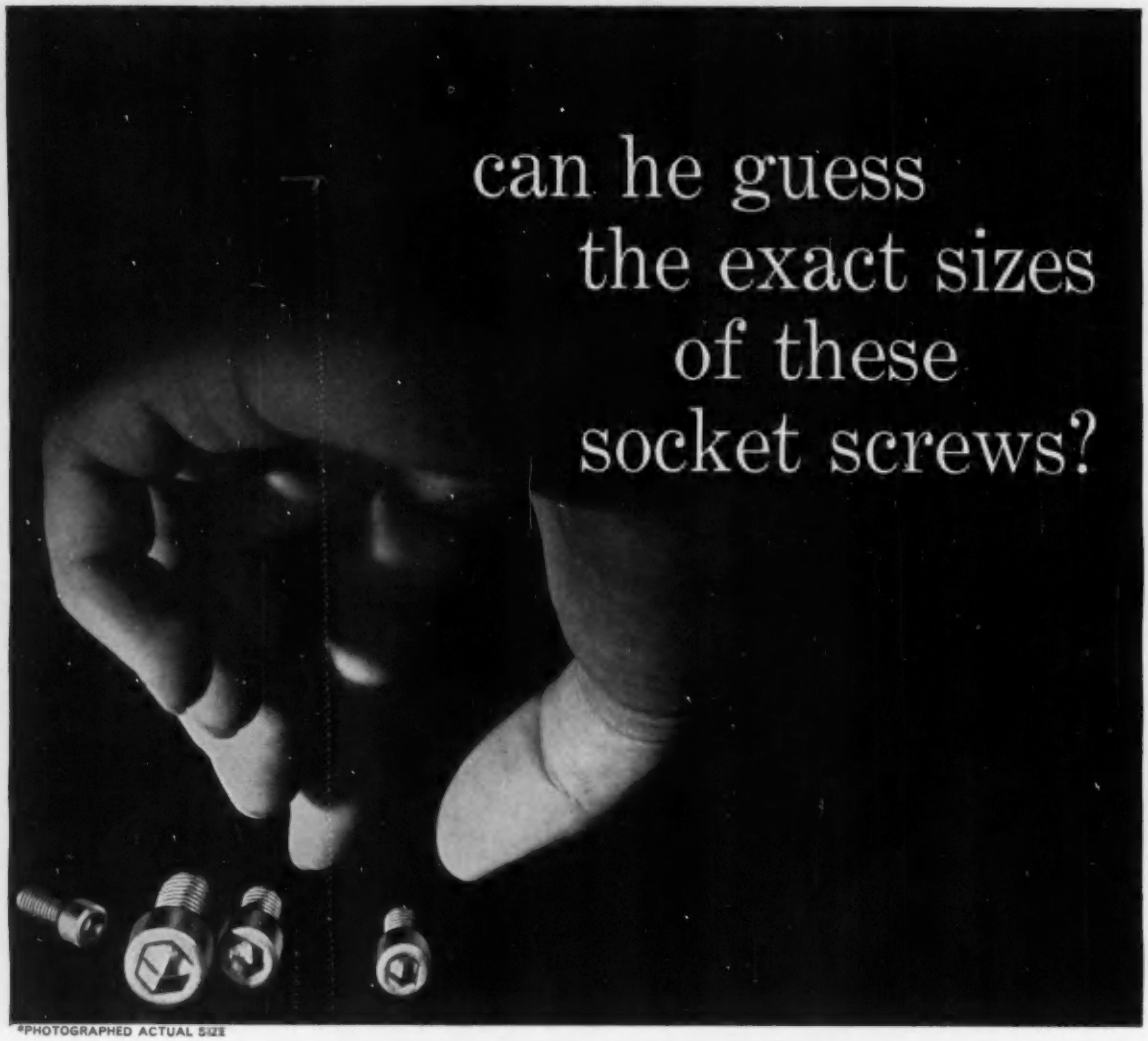
Please send me your free Quick Reference Catalog CC-400 containing basic information on all types of metal hose and tubing, fittings, etc.

NAME & TITLE.....

ADDRESS.....

COMPANY.....

CITY, ZONE, STATE.....



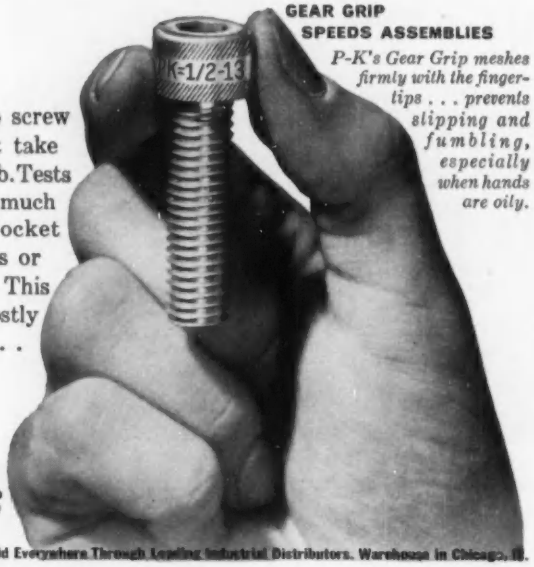
*PHOTOGRAPHED ACTUAL SIZE

Experts can usually tell the size of a socket head cap screw simply by looking at it. "Green hands", however, must take time out to "mike" before returning left-overs to the tool crib. Tests show that even some experienced workers guess wrong as much as half the time. With Parker-Kalon *Size-Marked* Socket Head Cap Screws on the job, there's no need to guess or "mike" for size. The size is clearly marked on the head. This exclusive P-K feature saves valuable time and eliminates costly errors. It's just one more reason why you can be sure . . . "if it's P-K, it's O. K."

*SIZES (L. TO R.) NO. 10, 3/8", 5/16", 1/4"

GEAR GRIP SPEEDS ASSEMBLIES

P-K's Gear Grip meshes firmly with the fingertips . . . prevents slipping and fumbling, especially when hands are oily.



PARKER-KALON® *fasteners*

Parker-Kalon Division, General American Transportation Corporation—Clifton, N. J. • Sold Everywhere Through Leading Industrial Distributors. Warehouse in Chicago, Ill.

Choose the best polystyrene for the job . . .

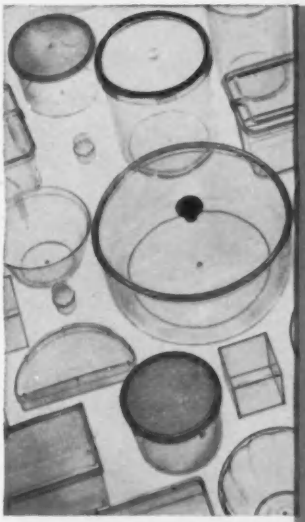
from the complete line of Dylene* plastics

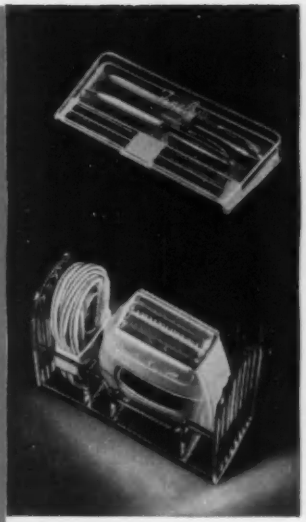
KOPPERS makes 19 formulations of Dylene polystyrene—to meet your exact requirements. Each plastic type has special characteristics to improve your product and make your production job easier and less costly.

Below are typical applications of four Dylene formulations. If you would like more information about the family of Dylene polystyrenes, write to Koppers Company, Inc., Chemical Division, Dept. PE-56, Pittsburgh 19, Pennsylvania.

DYLENE 2

Outstanding flow properties of this plastic make it extremely useful in large-area, thin-section moldings. In high speed, fully automatic molding machines, Dylene 2 fills molds quickly at lower cylinder temperatures than are usually required for general purpose polystyrenes. It is used to make disposable packages, "egg crate" lighting panels, picnic spoons and tumblers.



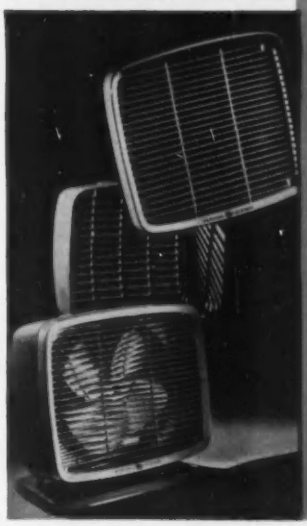


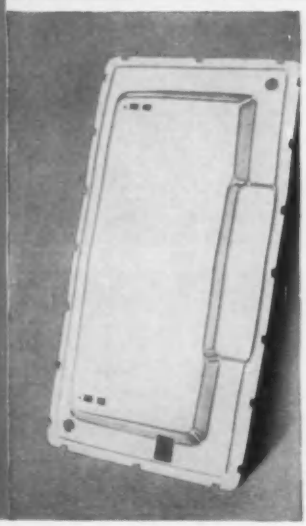
DYLENE 4

Easy flowing and fast setup characteristics make this plastic a real standout. Dylene 4 has greater strength and heat resistance than the usual easy flow polystyrenes. Result: faster cycling and ejection. This plastic is used to make combs, vials, thin-walled containers and display packaging items such as cases for pen and pencil sets and holders for electric shavers.

DYLENE 30

This medium impact polystyrene is not only easy to mold and fast to set up, but—it has a surface gloss and weld appearance that is almost indistinguishable from conventional polystyrenes. This unusual combination of properties makes this new plastic highly desirable for use in critical appliances such as air conditioner grilles, cosmetic caps and closures, housewares and toys.





DYLENE 200

Here is the easiest flowing polystyrene in the Dylene high impact line. Because of its easy molding properties, this plastic can be used in thinner sections than normal impact polystyrenes. It has excellent surface gloss and weld appearance. Dylene 200 is commonly used in refrigerator door liners, crisper trays, egg shelves, breaker strips and meat compartments, air conditioner grilles, housewares and toys.

*Koppers Trademark

KOPPERS

KOPPERS PLASTICS

SALES OFFICES: NEW YORK • BOSTON • PHILADELPHIA • ATLANTA • CHICAGO • DETROIT • HOUSTON • LOS ANGELES

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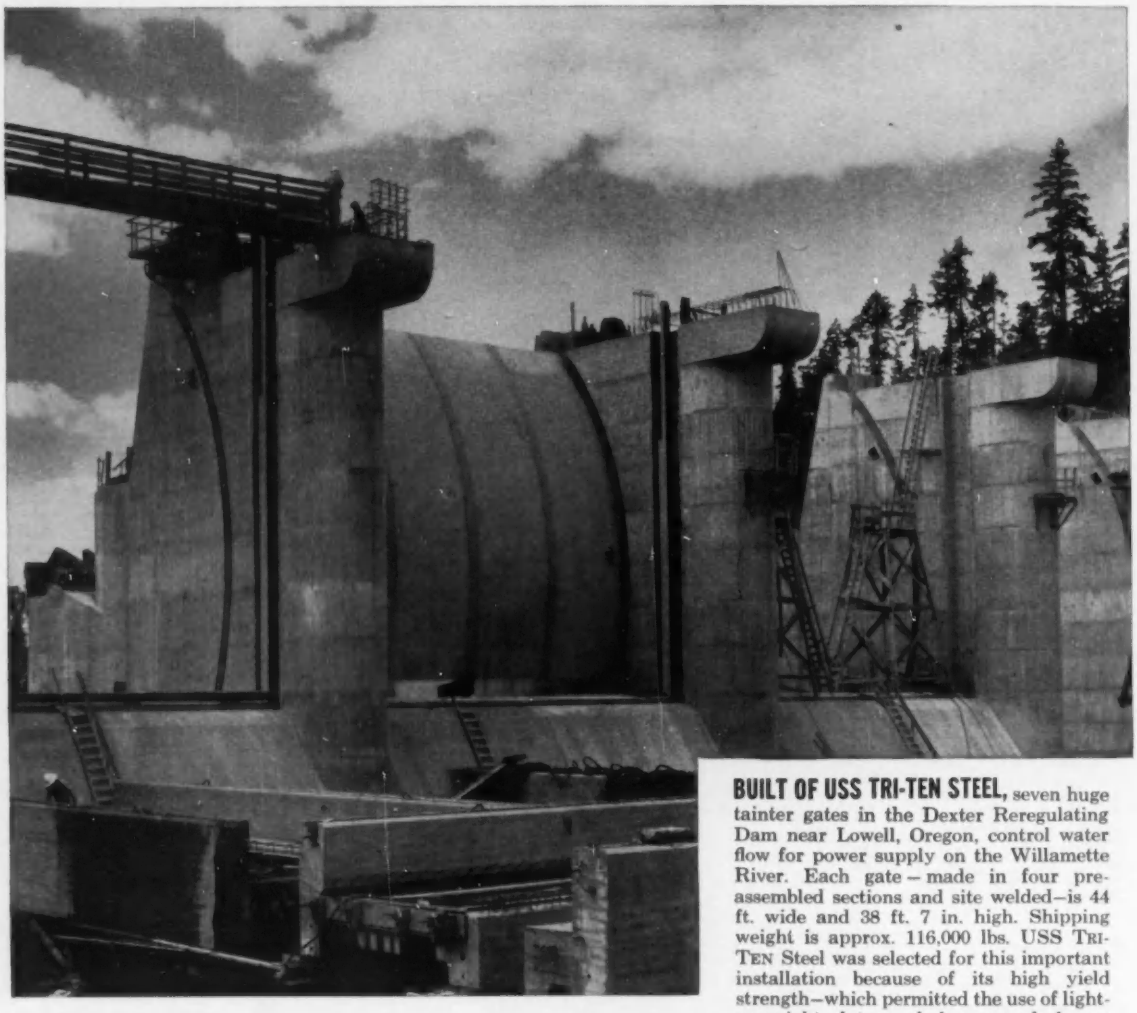
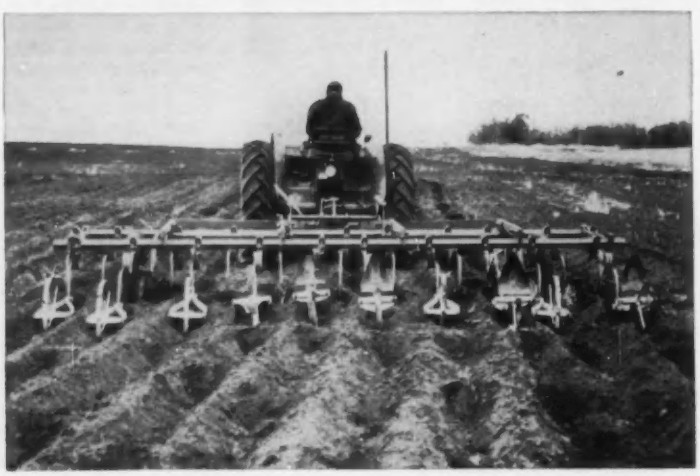
You can make it better



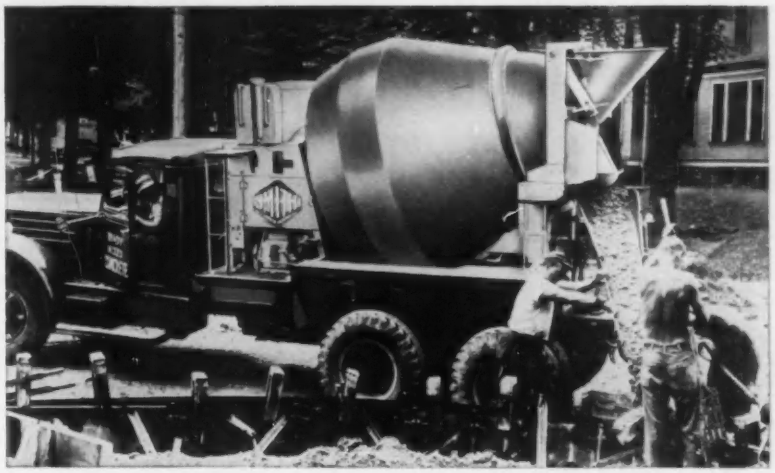
BUILT OF USS TRI-TEN STEEL, seven huge tainter gates in the Dexter Reregulating Dam near Lowell, Oregon, control water flow for power supply on the Willamette River. Each gate – made in four preassembled sections and site welded–is 44 ft. wide and 38 ft. 7 in. high. Shipping weight is approx. 116,000 lbs. USS TRI-TEN Steel was selected for this important installation because of its high yield strength–which permitted the use of lighter weight plates and shapes–and also on account of its higher corrosion resistance–equal that of copper steel. (Gates fabricated by Willamette Iron & Steel Co., Portland, Ore., for the Portland District of the Corps of Engineers.)



IN FARM EQUIPMENT, like this Rol-A Dam dammer built by Gunning Manufacturing Co., Lansford, N. D., the use of USS High Strength Steels in vital parts effectively increases life and dependability. Here, USS MAN-TEN Steel in the dammer blades provides superior abrasion resistance plus lightweight and extra strength and toughness. As one manufacturer puts it, "Because farm equipment takes terrific abuse in the field and is generally exposed to the weather without any protection whatsoever, we have found high strength steel construction a 'must'."

with USS High Strength Steels

CORROSION RESISTANCE is important in sign poles like this manufactured by C. J. Glasgow Company, Detroit, Mich. Due to the method of construction and design of upright and sign, the inside cannot be kept painted and is subject to corrosive damage. Built with USS COR-TEN Steel, which has 4 to 6 times the resistance to atmospheric corrosion of carbon steel, poles last 2 to 3 times longer. The higher strength of COR-TEN Steel also makes it possible to use steel in lighter gages, saving weight which reduces shipping costs and makes erection easier.



RESISTANCE TO ABRASION, plus the added strength and corrosion resistance supplied by USS MAN-TEN Steel, greatly reduce maintenance and add years of service life to the drum of this highly efficient concrete mixer, built by the T. L. Smith Company, Milwaukee, Wisc. MAN-TEN Steel's ability to resist the grinding action of stone, sand, slag and cement is so generally recognized that the use of MAN-TEN Steel in drums has become almost standard construction by leading manufacturers of truck mixers.

IN USS HIGH STRENGTH STEELS, design engineers have at their command three service-tested steels that will permit them to materially increase the efficiency and economy of machinery, equipment and structures at little or no increase in first cost . . . and frequently, at a saving.

All three of these famous "steels that do more" – USS COR-TEN, USS MAN-TEN and USS TRI-TEN – have a 50% higher yield point than ordinary carbon steel. All have better corrosion resistance and offer greater resistance to wear, fatigue and impact. Each, however, has specific superior properties that should be considered in determining its selection.

USS COR-TEN Steel, for example, is distinguished by its superior resistance to atmospheric corrosion—4 to 6 times that of carbon steel. USS MAN-TEN Steel is intended for weight reduction by means of greater strength in moderate forming applications, with enhanced resistance to abrasion and atmospheric corrosion. USS TRI-TEN Steel's outstanding characteristics are excellent weldability and resistance to shock at low temperatures.

Used singly or in combination, these steels can advantageously replace carbon steel to increase the strength and durability of vital parts *without* increasing their weight. Or when the use of thinner sections is feasible they can (1) reduce equipment weight without reducing its strength, or (2) increase the size and capacity of equipment without increasing total weight or the power required to move it.

You will find our 174-page *"Design Manual for High Strength Steels"* extremely useful in applying the benefits of these steels to your product. Send for free copy—simply write on your company letterhead to United States Steel Corporation, Room 5255, 525 William Penn Place, Pittsburgh 30, Pa.

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COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO • NATIONAL TUBE DIVISION, PITTSBURGH
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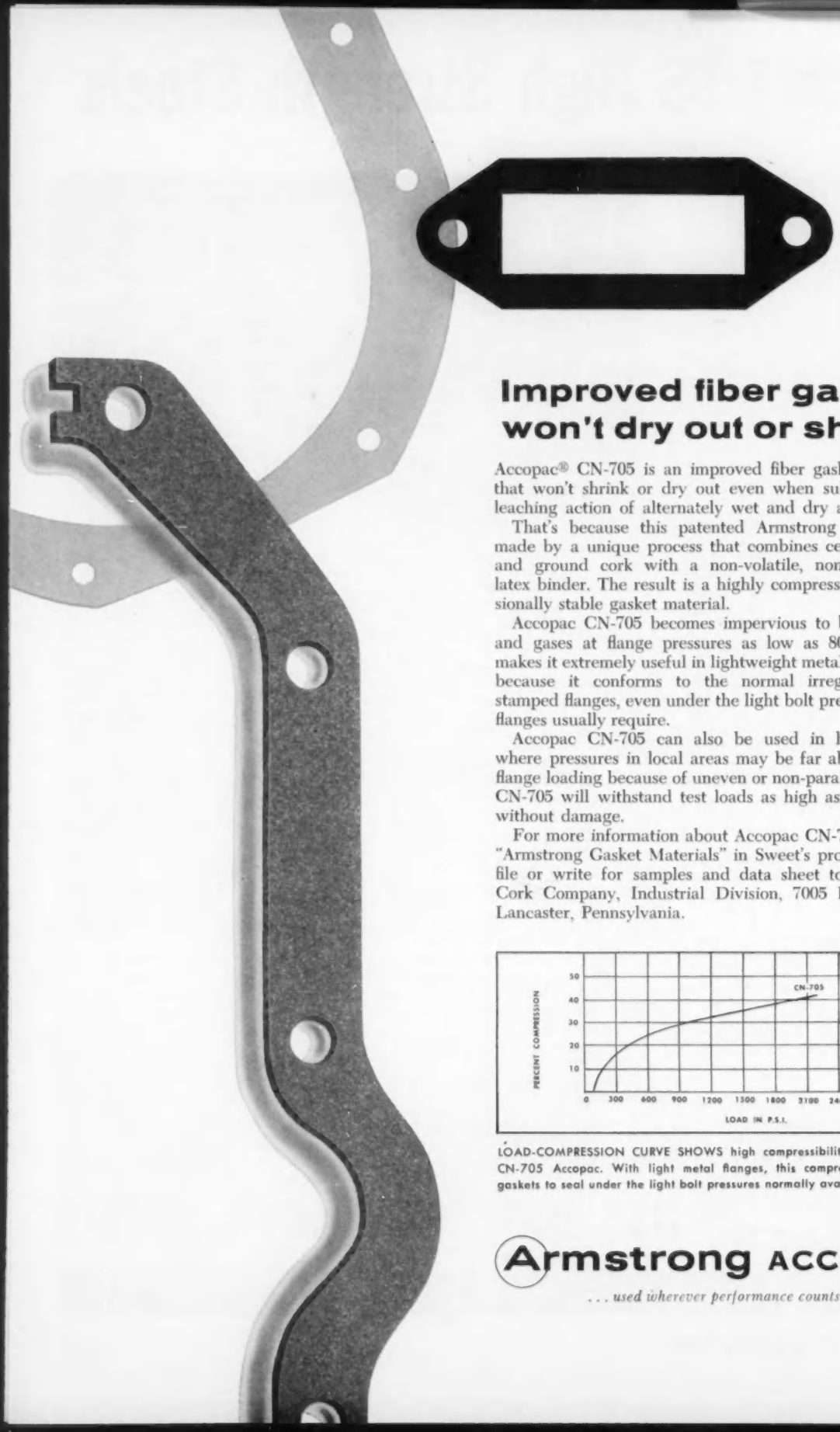
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

1933 UNITED STATES STEEL USS HIGH STRENGTH STEELS 1956
23 YEARS OF PERFORMANCE

USS HIGH STRENGTH STEELS

USS MAN-TEN • USS COR-TEN • USS TRI-TEN

UNITED STATES STEEL



Improved fiber gasket won't dry out or shrink

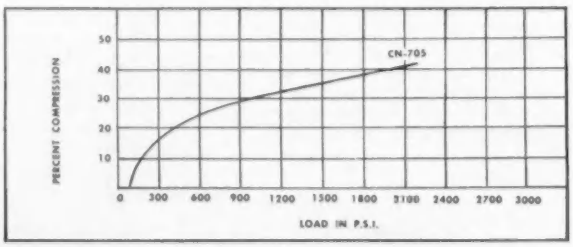
Accopac® CN-705 is an improved fiber gasket material that won't shrink or dry out even when subject to the leaching action of alternately wet and dry applications.

That's because this patented Armstrong material is made by a unique process that combines cellulose fiber and ground cork with a non-volatile, non-extractable latex binder. The result is a highly compressible, dimensionally stable gasket material.

Accopac CN-705 becomes impervious to both liquids and gases at flange pressures as low as 800 psi. This makes it extremely useful in lightweight metal assemblies, because it conforms to the normal irregularities in stamped flanges, even under the light bolt pressures these flanges usually require.

Accopac CN-705 can also be used in heavy joints where pressures in local areas may be far above normal flange loading because of uneven or non-parallel surfaces. CN-705 will withstand test loads as high as 100,000 psi without damage.

For more information about Accopac CN-705, look for "Armstrong Gasket Materials" in Sweet's product design file or write for samples and data sheet to Armstrong Cork Company, Industrial Division, 7005 Irvin Street, Lancaster, Pennsylvania.



LOAD-COMPRESSION CURVE SHOWS high compressibility of Armstrong CN-705 Accopac. With light metal flanges, this compressibility allows gaskets to seal under the light bolt pressures normally available.

Armstrong ACCOPAC

. . . used wherever performance counts

DOW CORNING CORPORATION

Silicone News

FOR DESIGN ENGINEERS No. 26

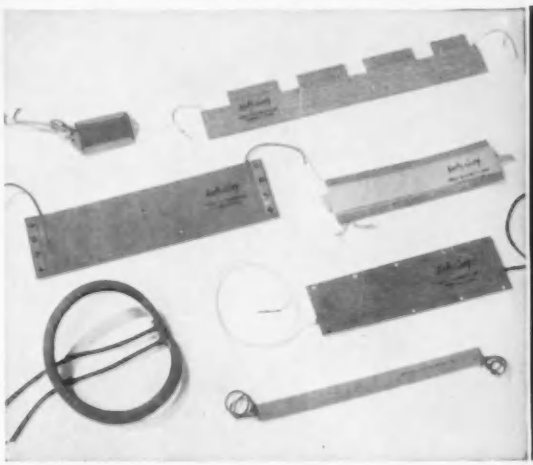
INCREASE ACCURACY OF SEXTANTS

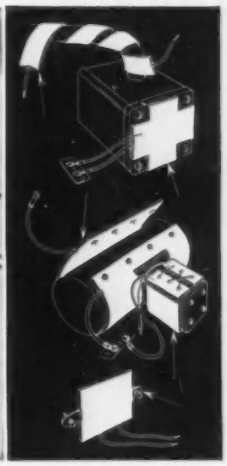
Air bubble rides in a chamber filled with a Dow Corning silicone fluid to improve the performance of one of the most accurate instruments ever developed for the celestial navigation of aircraft.

The periscopic sextant produced by Burton Manufacturing Co., Los Angeles, includes a timing and averaging mechanism, a controlled periscope, and a bubble-type sextant.

The silicone fluid used to help compensate for changes in ambient pressure and temperature during operation, was originally specified by the Bureau of Aeronautics and the Air Force. Developed especially for this application, Dow Corning F-323 Fluid has an extremely low cloud point and a viscosity of only 0.65 centistokes. Low viscosity minimizes bubble movement due to aircraft acceleration.

Freedom from clouding and low viscosity are retained at temperatures ranging from —65 to more than 170 F. The silicone fluid shows no sign of thickening, color change or gumming after more than 3 years of service. *No. 257*





AIRCRAFT WARM-UP TIME REDUCED BY SILASTIC INSULATED HEATERS

Meeting more closely than any other material the requirements of an ideal dielectric, Silastic® has proved its superiority in many applications ranging from traction motors to wire and cable. Here, for example, is how Silastic "R" Tape is used by Safeway Heat Elements, Inc., Middletown, Conn., to produce a line of woven resistance wire heaters that meet the demand for faster aircraft warm-up.

These heaters are made in a wide range of shapes and sizes for easy application to aircraft instruments which must be brought quickly to correct operating temperatures. The heating element is sandwiched between single layers of Silastic R Tape. The assembly is then vulcanized to form a void-free, moisture-proof jacket with maximum flexibility, minimum thickness and high thermal conductivity. Lead wires are insulated with a Silastic impregnated sleeving (Turbo 117) made by William Brand.

T. M. REG. U. S. PAT. OFF.

(cont'd. pg. 2)

Silicone Lubricant Improves Operation of Voice Recorder

To further extend the usefulness and maintenance-free life of their unique "Voice-Master" dictation recorder, Magnetic Recording Industries of New York has changed to silicone lubrication of all moving parts.

Since the consistency of the silicone lubricant remains relatively constant over a wide temperature span, the Voice-Master "can be moved directly from an automobile at below freezing into a warm room and operated immediately at proper speed." Moreover, relubrication of the unit is seldom, if ever, necessary.

Although the silicone lubricant costs more initially than the petroleum grease used previously, Magnetic reports the increased cost per unit is so low that "in reality it adds nothing to the cost of the complete Voice-Master." *No. 258*

CLASS H MOTOR STILL ON TEST AFTER 56,038 HOURS AT 240 C

At 10 A.M., June 6, 1946, a Class H insulated 5 hp motor was generator loaded to operate at its test temperature of 240 C in Dow Corning's motor test labs. Every 500 hours since it has been shut down and exposed to 100% relative humidity for 24 hours. As of 11 A.M. April 1, 1956, this motor was still on test after 56,038 hours at an average copper temperature of 240 C! That's equivalent to 341 years operation at the Class H temperature of 180 C.

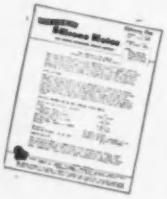
FOR DATA RELATING TO THESE ARTICLES, CIRCLE REFERENCE NUMBER IN COUPON ON NEXT PAGE

MORE

DOW CORNING CORPORATION

Silicone News

DOW CORNING PUBLICATIONS ON NEW DEVELOPMENTS AND TECHNICAL DATA . . . .



New booklet on Silicone Based Paints describes and illustrates how these heat, moisture, weather and oxidation resistant coatings improve product finishing and reduce maintenance costs on equipment ranging from industrial furnaces and exhaust stacks to domestic space heaters and garbage incinerators. Also explains difference between the straight silicone and modified silicone paints now available from more than 50 formulators listed as sources of supply. *No. 262*

Dow Corning Silicone Defoamers kill foam in a variety of products and processes without risk of contamination. Effective concentrations range from 0.1 to 200 parts per million. Properties and typical applications are described in a new informative reference brochure. *No. 263*

Complete Listing of manufacturers of silicone (Class H) insulating components is now available. Designers and builders of electric machines and electronic equipment may want to refer to these Sources of Supply. *No. 264*

Silastic 6526, a recently introduced silicone rubber stock, combines serviceability from below —100 to +500 F with low compression set characteristics without the use of toxic additives. Parts molded or extruded from this Silastic material have good physical properties after short cure. *No. 265*

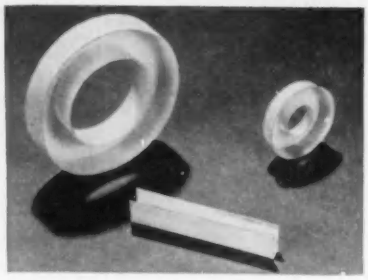
Now available—1956 Reference Guide to Dow Corning Silicone Products. A concise, comprehensive, 12 page reference that is convenient-to-use. It's packed with data, properties, and information on how you can use silicones in designing new equipment, improving performance and reliability of original equipment, or reducing production and maintenance costs. *No. 266*

"151 Uses for Silicones in Metalworking." A reprint from STEEL, condenses and lists known applications for silicones in Design, Production, Maintenance and Miscellaneous categories. Provides a quick reference as to how Dow Corning Silicones help solve problems in many segments of the metalworking industry. *No. 267*

CLASS H SILICONE-GLASS PARTS SAVE SPACE, SPEED ASSEMBLY

Excellent post-formability of parts made with Dow Corning silicone bonded glass cloth contributes to growing market developed by Stevens Products, Inc., East Orange, N. J. Such parts cut assembly time, save space, give long service at Class H temperatures in motors and generators.

Custom-designed to displace assemblies that are normally taped, Stevens Products has developed a variety of post-formed silicone-glass laminated parts that eliminate seams, give more reliable performance and save assembly time and labor. A 2-ply interpole assembly, for instance, involves only two parts compared to six parts and the taping operation previously required. Over 1 million of these assemblies have been manufactured to date for use in generators.

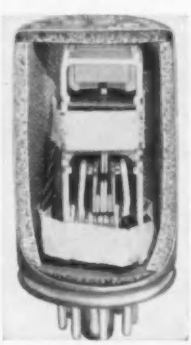


Other post-formed silicone laminated parts include rotor covers, end caps, shaft collars, slot liners and bobbins, as well as insulating covers for a wide variety of electric and electronic parts. Rigid rectangular or circular tubing is also fabricated for transformers. Many of these parts involve complex configurations and deep draws. *No. 260*

SPONGE SILASTIC PROTECTS DELICATE ELECTRONIC GEAR

Because Silastic, Dow Corning's silicone rubber, stays soft and resilient at temperatures from —100 to 500 F, designers at Airpax Products Co., Baltimore, use this material to cushion their cycle choppers or contact modulators.

Airpax uses a layer of sponged Silastic on all cycle choppers to protect relays from shock and vibration, and to reduce transmission of acoustical noise to the housing.



The latest model, a 400 cycle, 6 volt unit identified as the A-100, is designed to operate in ambients ranging from —65 C to 200 C. It opens and closes its contacts 1,440,000 times per hour and is hermetically sealed to prevent entry of dust or moisture.

According to Airpax, "The Silastic sponge not only helps the unit withstand well over 10G vibration and over 50G shock, but is the only known material which will maintain its virtues when the chopper is exposed to the terrific temperature extremes found in airborne miniaturized equipment." *No. 261*

SPEED AIRCRAFT WARM-UP *(continued)*

Single and double circuits are available in watt densities ranging up to 40 watts per square inch. Double circuits over the entire area assure fast warm-up and continued warmth.

Safeway heaters may be tied, bonded, snapped or bolted into position. Typical applications include gyros, bearings, cameras, valves, hoses and pitot tubes. Such heaters are also immersed in fluids that must be quickly heated or maintained at optimum operating temperatures.

Although surface temperatures of many of the thousands of heater units now in service exceed 450 F, not a single failure of the Silastic insulation has been reported. *No. 259*

Dow Corning Corporation, Dept. 8605, Midland, Michigan

Please send me: 257 258 259 260 261
262 263 264 265 266 267

NAME _____

TITLE _____

COMPANY _____

STREET _____

CITY _____ ZONE ____ STATE _____

SILICONE NEWS is published for product design and development engineers by

DOW CORNING CORPORATION
MIDLAND MICHIGAN

first in silicones
DOW CORNING SILICONES

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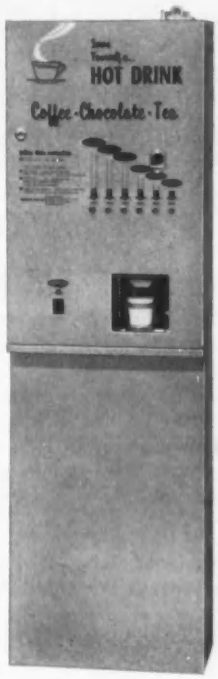
How to Keep Drinks Hot

No. 6 of a series — *Showing the Broad Application Range of Fenwal Controls*

You need hot water for good coffee, tea or hot chocolate. And the Fenwal Thermoswitch Control makes sure this machine always has water at the right temperature. Here's how.

A Fenwal Snap-Action THERMOSWITCH unit, No. 20102, skeleton frame immersion type, with a standard snap-action switch "S", 100-300°F range, controls a 1400 watt 110 Volt AC heater in a half gallon hot water tank. The THERMOSWITCH is preset at 160°F ±5°F, and is mounted vertically in top of tank. The heater is mounted from the bottom of tank. (Another Fenwal THERMOSWITCH unit, the series 30000, controls the internal cabinet temperature.)



FENWAL THERMOSWITCH® unit, series 20000, is installed in this Superior Hot Drink Bar, manufactured by the Superior Manufacturing Corporation of Denver, Colorado.

How Fenwal Thermoswitch® Series 20000 Operates

The Fenwal Snap-Action THERMOSWITCH unit provides fast response because the fluid completely surrounds the bellows and is in direct contact with the external shell. The contacts in the head of the unit are actuated by a push-rod connected to the bellows. Units are available in six UL listed temperature ranges: Series 20000: −75°F to 125°F; 25°F to 225°F; 100°F to 400°F. Series 21000: −75°F to 175°F; 0°F to 250°F; 50°F to 300°F.

Proved Applications

Fenwal Sales Representatives and Engineers have saved time, trouble and money in all types of plants and laboratories by solving thousands of temperature control and detection problems. Fenwal THERMOSWITCH units are controlling processes that involve liquids, gases and solids.

Put Fenwal's vast reservoir of technical know-how to work for you. Chances are your problem has already been met and mastered by Fenwal engineers.

Write for new Snap-Action Catalog for details and complete information.

FENWAL INCORPORATED
25 Pleasant Street
Ashland, Mass.

Please send me your Snap-Action Catalog.

Our specific problem is:.....

.....

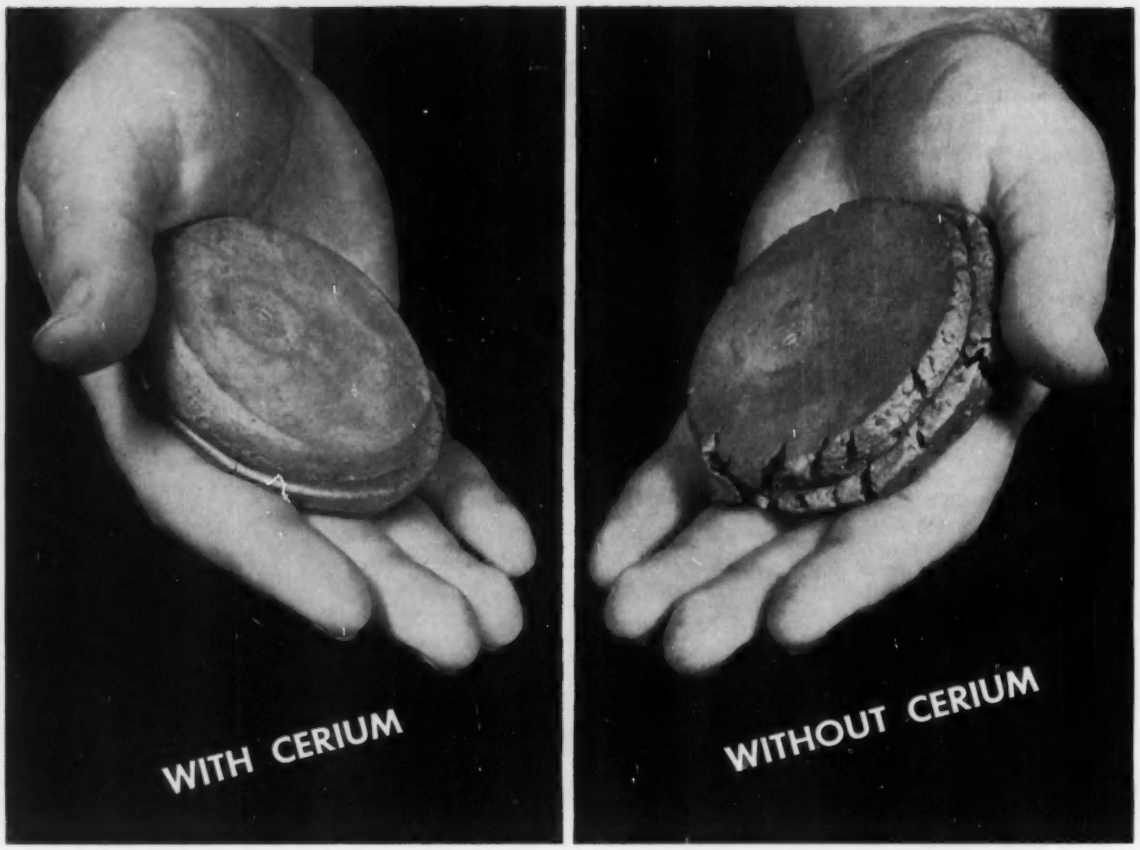
.....

Name.....*Title*.....

Address.....

City.....*Zone*...*State*.....

Fenwal **CONTROLS TEMPERATURE . . . *PRECISELY***



HOW *Carpenter* USES RARE EARTH ELEMENTS TO IMPROVE FORGEABILITY OF ALLOYS FOR ELEVATED TEMPERATURE SERVICE

The value of rare earth elements in certain alloys for elevated temperature service can be seen in this hot forgeability test. Cast cones, identical except for the addition of cerium in one, are heated to forging temperature and upset or hammered into flat "pancakes". Note the relative freedom from cracks and tears in the specimen containing cerium.

What does this improved hot workability mean to you? It means better forged finishes requiring less machine clean-up . . . less wasted steel . . . fewer rejects . . . faster fabricating.

Carpenter alloys for elevated temperature service have an enviable reputation for improved forgeability, and exceptional cleanness which meets the strictest inspection requirements.

Carpenter pioneering in tool steels, super corrosion resisting steels and free-machining stainless steels has helped hundreds of companies to improve products and cut costs. This same specialty mill experience can help you do a better, low cost job on any parts or products you make for high temperature service. It'll pay you to investigate. Contact your Carpenter Representative, or drop us a line on your company letterhead. *The Carpenter Steel Company, 117 W. Bern St., Reading, Pa.*

Specify Carpenter alloys for elevated temperature service and get these three big advantages . . .

Improved Forgeability
Greater Uniformity
Cleaner Steel

Carpenter STEEL

Improved Alloys for Elevated Temperature Service

Anaconda specifies Enjay Butyl rubber

TO DEFY OZONE IN HIGH-VOLTAGE CABLES...

for more current per circuit...more power per dollar

Anaconda specifies Enjay Butyl insulation for high-voltage cables because this rubber has incredible resistance to ozone. Surpassing the industry's standard three-hour specification test, Enjay Butyl insulation used by Anaconda showed *no injury after 72 hours* of ozone concentration tests—24 times longer than specification requirements. Other rubbers would deteriorate and crack in a fraction of this time.

With the help of Enjay Butyl, millions of feet of Anaconda's cable now in use deliver more current per circuit, more power per dollar.

Perhaps *your* product, too, can be improved with versatile Enjay Butyl. It comes in non-staining grades for white and light-colored parts, offers excellent electrical properties, low price and *immediate availability*. For full information, contact the Enjay Company. Complete laboratory facilities and technical assistance are at your service.

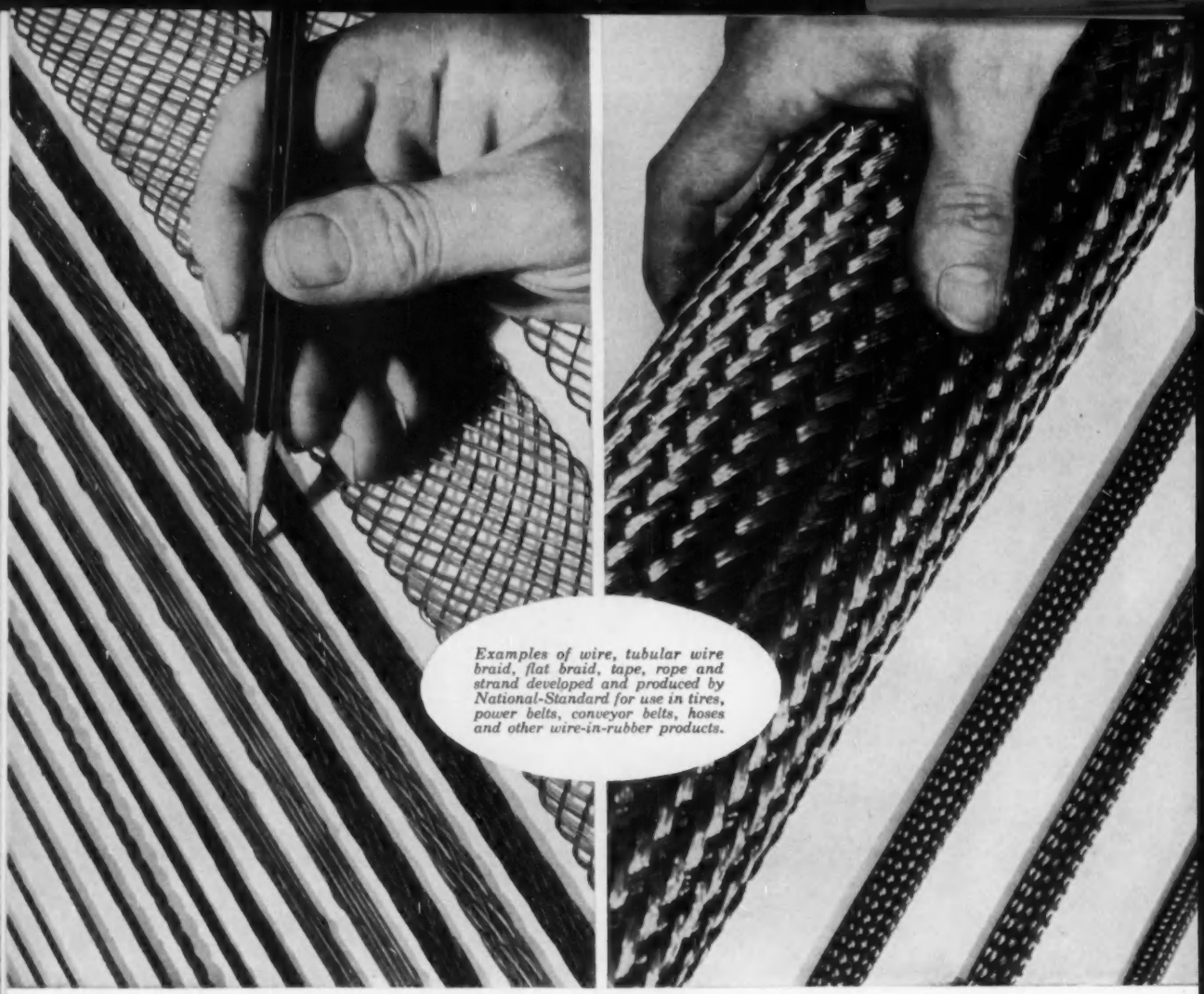
ENJAY BUTYL

Enjay Butyl is the super-durable rubber with *outstanding* resistance to aging • abrasion • tear • chipping • cracking • ozone and corona • chemicals • gases • heat • cold • sunlight • moisture.

ENJAY *Pioneer in Petrochemicals*

ENJAY COMPANY, INC., 15 West 51st Street, New York 19, N. Y.

Other offices: Akron • Boston • Chicago • Los Angeles • Tulsa



Examples of wire, tubular wire braid, flat braid, tape, rope and strand developed and produced by National-Standard for use in tires, power belts, conveyor belts, hoses and other wire-in-rubber products.

How product "X" might be improved

● Whatever you make, from cheese slicers to electronic brains, chances are wire of some kind in some form enters into your product make-up. Maybe it isn't special wire. Maybe it should be! In either case it is in this area that National-Standard service might help you produce a better product at lower cost.

For example, National-Standard has long devoted large scale research and engineering to improving the teamwork of wire and rubber—extensive work on wire fabrication, material, finish, corrosion, strength, elongation, adhesion and other factors that affect the behavior and cost of wire-in-rubber products.

You can draw on the fruits of all this and similar work performed for many other industries on the most effective use of wire.

So if you even suspect that a different or specially developed type of wire might improve your product or speed production, don't hesitate. Consult with National-Standard. We make a point of such service . . . want to be of help . . . and are geared to do it well, without obligation. Check with us now . . . or any time!

NATIONAL-STANDARD COMPANY • NILES, MICHIGAN
Tire Wire, Stainless, Fabricated Braids and Tape

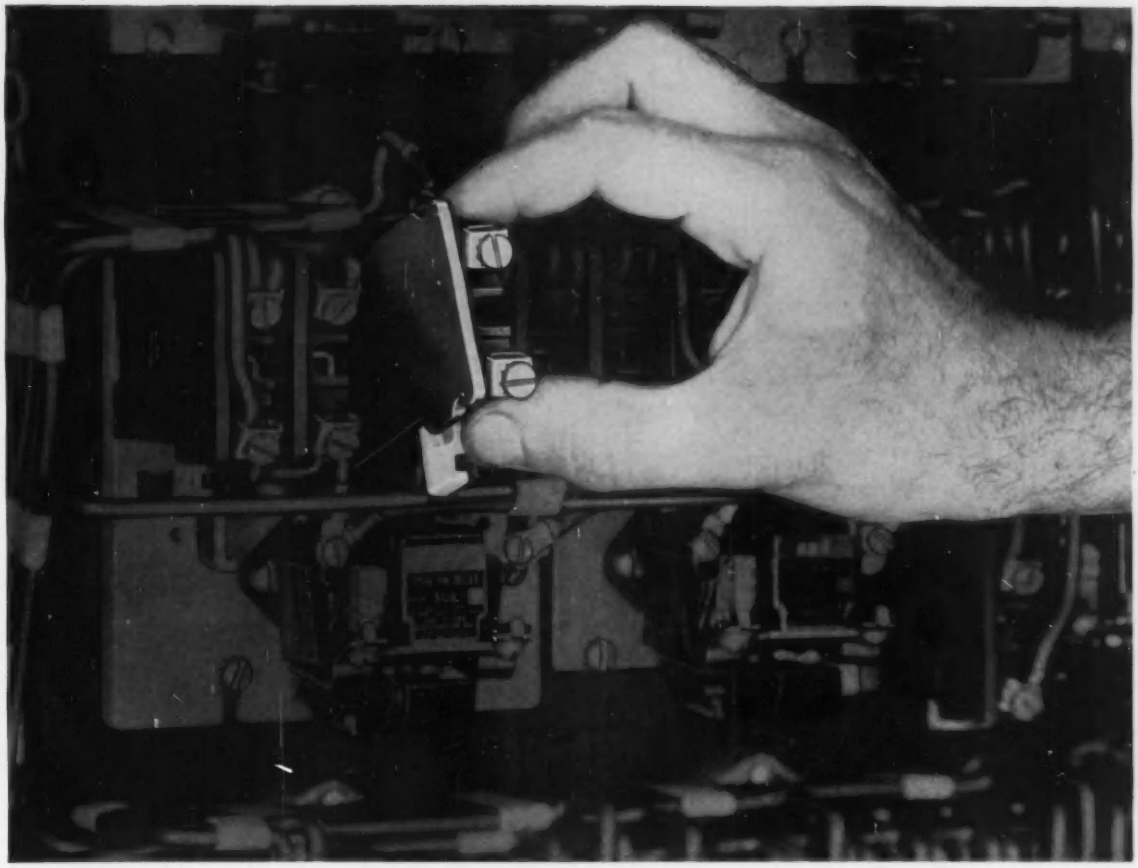
ATHENIA STEEL DIVISION • CLIFTON, N. J.
Flat, High Carbon, Cold Rolled Spring Steel

REYNOLDS WIRE DIVISION • DIXON, ILLINOIS
Industrial Wire Cloth

NS NATIONAL-STANDARD Company NILES, MICHIGAN

WAGNER LITHO MACHINERY • JERSEY CITY, N. J.
Special Machinery for Metal Decorating

WORCESTER WIRE WORKS DIVISION • WORCESTER, MASS.
Round and Shaped Steel Wire, Small Sizes

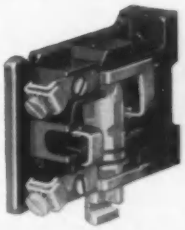


You can easily remove a single pole from any CLARK Type "PM" Relay

Each pole in the new CLARK heavy-duty relays is an integral unit that can be quickly removed or replaced *from the front* without disturbing other poles. You need disconnect only two wires and loosen one mounting screw—regardless of the number of poles in the relay. Compare this with other types of relays where the whole device must be removed to accomplish the same thing. For example, with a conventional 6 pole relay, 14 wires and 3 mounting screws must be removed.

All terminals are located on the front. They are "pressure" type, eliminating need for looping wire. Coil-changing and magnet replacement can also be done quickly from the front without removing relay from panel.

Write for Bulletin PL-7305



Each pole is contained in its own melamine housing.

A short circuit through one set of contacts is confined to a single pole and will not destroy the whole relay. Enclosed top protects from dust and dirt, and serves as wiring shelf.

The **CLARK CONTROLLER** *Company*

Engineered Electrical Control

1146 East 152nd Street • • Cleveland 10, Ohio

IN CANADA: CANADIAN CONTROLLERS, LIMITED • MAIN OFFICES AND PLANT, TORONTO

Man without a hoe

This cornfield once looked hopelessly over-grown with weeds.

Now the weeds are under control. *Yet not a single hoe ever touched the soil.*

Give the credit to 2,4-D, an amazing chemical discovery. It destroys only broad-leaved weeds. And gives food plants like corn, wheat, rice, oats and barley a new lease on life!

Unlike older weed killers, 2,4-D is a hormone-type herbicide. It disrupts the normal growth of broad-leaved weeds. In three or four weeks, they're *dead.*

What's 2,4-D? Actually, 2,4-dichlorophenoxyacetic acid. And there were tough problems to overcome at nearly every stage of its development.

Corrosion, for example, was a constant threat to the life of equipment — and to the purity of the final product. So Nickel and Monel* nickel-copper alloy are specified for pipes and fittings, steam coils, reactors, centrifuges, dryers, tanks and other equipment used in making and handling 2,4-D.

Nickel and Monel nickel-copper alloy protect product purity. And they resist corrosion as few metals do!

Tuck that information away where it will be handy. You may be able to use it in solving a problem of your own.

Better still, do this — now. Send for "Standard Alloys for Special Problems." This booklet summarizes the properties, applications and available forms of all the Inco Nickel Alloys. Write us for a copy. Use it to help you select the most suitable metal for *your* job. The International Nickel Company, Inc., 67 Wall Street, New York 5, N. Y.

INCO TRADE MARK

INTERNATIONAL NICKEL

Nickel Alloys Perform Better, Longer

*Registered Trademark of The International Nickel Company, Inc.

tough, versatile

U.S. Royalite the sheet fabricating material that turns designers' dreams into practical realities

Is the case, cabinet, cover or other part of your product now made of a material which leaves something to be desired in . . .

Economy? Royalite® assures exact, inexpensive prototypes . . . lower tooling, finishing and assembly cost . . . fewer operations.

Beauty? Royalite molds readily to shape, detail and contour . . . retaining its eye-catching, sales-appealing color and texture.

Durability? Patented compounding of thermoplastic fortified with rubber gives never-before wearability. It's super-tough to resist impact . . . yet weighs less than any metal. Custom formulized to meet specific needs such as oil and chemical resistance, moisture-resistance, and performance at extremes in temperature.

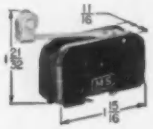
See these designers' dreams come true at the Royalite Display, Design Engineering Show, Convention Hall, Philadelphia . . . May 14 to 17—Booth No. 130

United States Rubber

2638 N. Pulaski Road, Chicago 39, Illinois

Uses Unlimited for

Control gaging cycle of from 60 to 120 parts a minute



An electronic sorting gage automatically sorts mica parts at the rate of from 60 to 120 pieces per second with help of two MICRO precision switches. The parts are sorted into eight different thickness classifications. The gaging cycle is initiated by the operator who breaks a photoelectric beam with the piece of mica in the hand. The switches are operated by timing cams to control the various steps.

Three factors—extreme precision, accurate repeat operation and long-life dependability—were MICRO SWITCH characteristics that influenced their choice.

Speed operation of Comparators by 50%

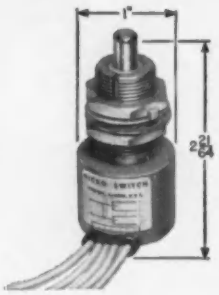
Two MICRO precision switches help make the operation of an optical comparator faster, safer and more automatic. Used as upper and lower vertical limit switches, they make it impossible to raise or lower the work table beyond previously adjusted limits.

This process speeds work up to 50% by leaving the operator free to position his work quickly without fear of damage to the machine.

The switches used were chosen because of their quick and dependable response, their sealed plungers to resist entrance of dust or dirt and their convenient mounting and wiring arrangements.

6 switches indicate fighter wing flap position

Six of these new cylindrical switch assemblies are used on a military fighter plane to let the pilot know the position of his wing flaps.



The aircraft engineers told us that the MICRO precision switches were chosen because (1) space was very limited (2) the switch was exposed to ice, oil and dust and required an excellent seal and (3) absolute reliability was mandatory.

64 Subminiature Switches in Airborne Navigation System

Sixty-four MICRO Subminiature Switches, grouped on a panel which measures but 5¾" wide by 7¾" long, perform important functions in the card reader of an airborne navigation system.

The switches are actuated by holes in punched cards and transfer information from the cards to the computer which gives the information to enable a pilot to fly a selected course.

Engineers chose MICRO Subminiature Switches because they combine unusually small size with the utmost precision and reliability required in such delicately adjusted equipment.

How a mercury switch adds to your barber shop shave

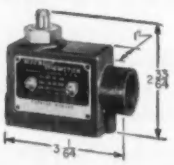
Lather that oozes into your barber's hand from his counter dispenser, does so because of the action of a HONEYWELL Mercury Switch.

Depressing a plunger on top of the dispenser tilts the mercury switch. This starts a motor and the lather is delivered by the turn of a plastic worm screw. The switch fits easily into a streamlined design and is unaffected by the moist environment.

Small HONEYWELL Mercury Switches such as this meet the demands of small load circuits and applications where space and economy are critical factors. They are widely used by designers of animated displays, control and indicating devices, home freezer units, alarms and in hundreds of other tilt motion, low force applications.

31 MICRO precision switches in automatic riveting press

MICRO SWITCH enclosed switches are used to give foolproof control of the various steps of an hydraulic riveting press. Thirty one switches control the ten automatic operations by which a plate is riveted to an aircraft crankshaft.

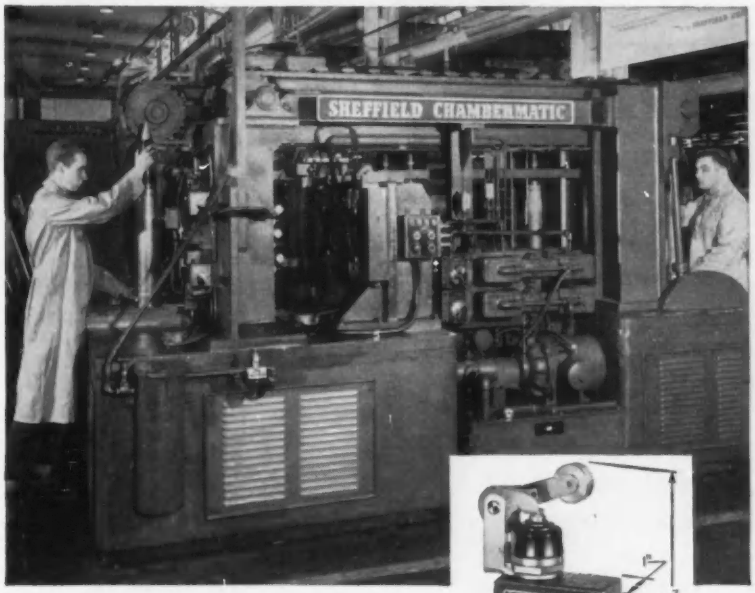


Automatic action of the switches protects press and crankshaft alike against damage caused by misalignment of the part being processed or from carelessness on the part of the operator. It is impossible to operate the press unless parts are properly seated.

The designers chose MICRO SWITCH controls for this highly complex equipment because of their recognized precision, dependability, sturdy construction and long-lived performance.

MICRO precision switches

...THEIR USE IS A PRINCIPLE OF GOOD DESIGN

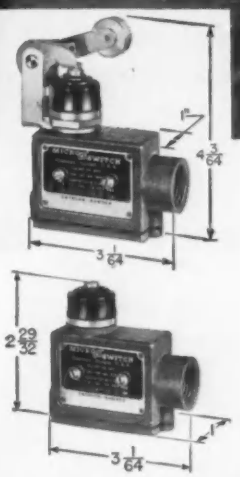


"Inspects" ammunition rounds—one every four seconds

MICRO precision switches—34 of them—perform key functions in an automatic gage, perhaps the largest ever built. Fully loaded ammunition rounds, weighing 43 pounds, are given final checking for profile and alignment at the rate of one every 4 seconds. The result is increased assurance of uniformity and lower inspection costs.

The switches control each step of the electro-pneumatic gaging cycle, position the shells on the conveyor and stop the machine at any deviation from normal. Engineers chose MICRO SWITCH for:

- **Extreme reliability of performance**
- **Long life dependability of operation**
- **Low actuating force required**
- **Small size with rugged construction.**



Heavy duty switch operates 57,000 times a day with precision

MICRO precision switches are designed for *both* precision and reliability. As precision switches for the control of the steps of an automatic grinder they had to be ruggedly housed, unaffected by oil splash, conveniently mounted and actuated. In addition, they had to be capable of sensitive, high-speed operations—some of them every 1½ seconds, three shifts a day. This means 57,000 precise operations in a 24 hour period, day after day.

Three different types of switch actuation were required—roller arms, rollers and straight plungers. Versatile adjustment of roller arm and roller mechanisms in these MICRO heavy duty switches permitted mounting in minimum space.

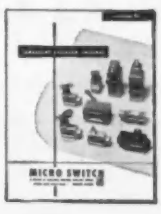
Let MICRO SWITCH Engineering Service be your short cut to better design

MICRO SWITCH Engineering Service is made up of experts on just one thing—precision switching problems.

Whatever your design problem, its solution may easily be expedited by consultation with an engineering service that has helped in the solution of many complex electrical switching problems.

MICRO SWITCH may have already solved a problem similar to yours—for somebody else. Should your problem turn out to be entirely new, MICRO SWITCH can—and will—develop the switch you need.

Send for new Catalog 83 on Industrial enclosed switches.



MICRO SWITCH Engineering Service is available to help you select the exact switch or switches suited to your requirements. Branch offices are located in key cities.

MICRO SWITCH

A DIVISION OF MINNEAPOLIS-HONEYWELL REGULATOR COMPANY

In Canada, Leaside, Toronto 17, Ontario • FREEPORT, ILLINOIS

Send for Free 3-D Booklet on Forgings by CHASE®!

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PLEASE SEND ME YOUR THREE-DIMENSIONAL BOOKLET ON NON-FERROUS FORGINGS, COMPLETE WITH VIEWING GLASSES. I want to see for myself how forgings by Chase can give me economical parts that have higher tensile strength, smoother surfaces and require less machining and finishing.

Quality costs less than you think with die-pressed forgings by Chase®!

Even the finest sand castings look crude when compared with Die-Pressed Forgings by Chase! For the Chase forging process results in dense, smooth-surfaced pieces with remarkable precision in dimensions and detail.

That's why forgings by Chase can be so economical for you! They require far less machining and surface finishing. Rejections *after* machining are greatly reduced because these pieces are close-grained, non-porous and virtually free from sub-surface imperfections.

Get *stronger*, more efficient and attractive parts that are completely interchangeable with absolute minimum hand fitting! Find out about non-ferrous forgings by Chase, blank or machined and polished and plated if desired. Send the coupon above, today!

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SUBSIDIARY OF KENNECOTT COPPER CORPORATION
WATERBURY 20, CONNECTICUT

Designer's Digest

PRODUCT HIGHLIGHTS

General Electric Speed-Measurement Systems Now Tailor-Made to Suit Your Needs

These low-cost and highly accurate components add beauty and quality to your product.

General Electric's complete line of a-c and d-c tachometer generators and indicating or recording instruments provide you with a low-cost answer to your speed measuring problems. Every system is tailor-made to your needs and all components are calibrated together at the factory to assure you highly accurate operation on your equipment.

SMALL IN SIZE, these tachometer generators are ideal for measuring speed on machines where space is at a premium and where accurate speed indication is necessary for quality control and protection of expensive machinery.

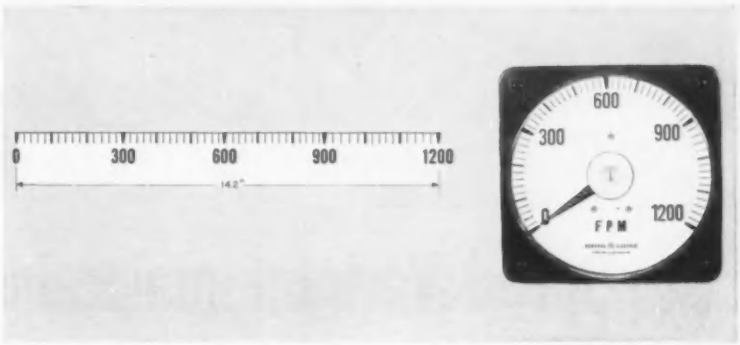
TOTALLY ENCLOSED, all G-E tachometer generators are protected from dirt, dust and other foreign matter which might affect operation.

ANY LEGEND you desire will be marked on your G-E tachometer indicator scales. Your instrument can be calibrated in units such as feet per minute, inches per minute, spindle rpm or any related speed. Manufacturer's or customer's name may also be imprinted on the scale face.

FOR GENERAL-PURPOSE NEEDS, a Model 1E148 tachometer generator used with a Type DB-18 tachometer indicator provides a speed measurement range of 100 to 5000 rpm.

LOW-COST SPEED CONTROL, as well as accurate speed indication, is furnished by G.E.'s D-C tachometer generator 9894743 in a wide variety of applications.

FOR MORE INFORMATION write for Bulletin GEC-1258 to Section 585-43, General Electric, Schenectady 5, N. Y.



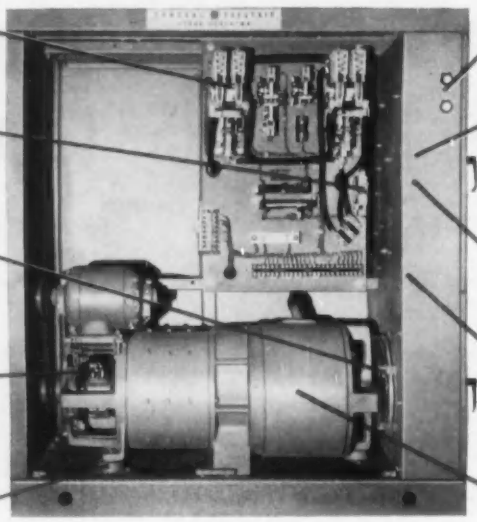
HANDSOME DESIGN and top quality of DB-18 indicator help make your product more saleable. Long scale and clear, shadow-proof glass give telescopic readability.

WEIGHING ONLY 5 POUNDS this 1E148 generator has a speed range of 100 to 5000 rpm and is suitable for most general-purpose needs.

DESIGNED FOR MINIMUM SPACE, this 9894743 generator can be either flange or foot mounted. Two models: 50-v or 100-v per 1000 rpm.

TURN THE PAGE FOR MORE G-E PRODUCT HIGHLIGHTS

Designer's


Full capacity d-c magnetic blowout contactors lengthen life of the contact tip.
Complete protection of d-c drive motor and generator by d-c overload relays.
Shaft-mounted fan keeps cabinet pressurized—helps keep dirt out.
Large openings in end shield allow easy inspection of brushes and commutator.
Self supporting m-g set specially mounted to help prevent vibration.
Simple, start-stop push button.
A-c undervoltage protection. Protection of a-c equipment by a-c overload relays.
A-c short-circuit protection.
A-c control in isolated compartment.
Dependable, powerful motor-generator set matches overload capacity of the d-c drive motor.

Speed Variator maintains constant surface cutting speed over 20:1 range

Packaged unit helps save up to 47% machining time on 8-foot vertical boring mill

G-E engineering know-how helped coordinate the electrification of this Giddings and Lewis 8-foot vertical boring mill which can save up to 47% machining time with improved surface finish. A G-E 75-hp electronic Speed Variator drives the main table. Mounted on the left rail head is a potentiometer sensing element which sends signals to the Speed Variator, thus maintaining constant surface cutting speed over a 20:1 range of work diameters.

In addition to maintaining constant surface cutting speed as the diameter of the work changes, and maintaining constant chip thickness, the G-E drive provides electronic two-dimensional tracing. G.E.'s two-dimensional tracer head controls the ram and saddle motions. Each of these motions has a 1½-hp d-c motor, amplidyne-generator* feed drive which operates to move the tool in the required direction to automatically duplicate the shape of the template in the work piece. GEA-6127 describes the Speed Variator.

** The Amplidyne—rotating amplifier developed by General Electric—the heart of this and many other systems requiring the maximum in reliability and precision.*

GENERAL ELECTRIC

Digest

PRODUCT HIGHLIGHTS

Smaller, more versatile General Electric Strongbox solenoids solve many design problems

Built to meet modern industry's requirements of top performance and dependability, General Electric Strongbox solenoids offer design engineers many important advantages.

LONGER LIFE is assured when you use G-E solenoids in your products. The Strongbox coil is completely moistureproof and is protected from accidental damage. Hydraulically riveted, silicone-steel laminations in plungers and frames resist vibration and separation even after repeated use, and glass-fabric plunger guides keep friction to a minimum.

DESIGN FLEXIBILITY is greater. G-E Strongbox solenoids can be mounted in any one of five positions. Wiring is made easy because the coil has both leads and built-in terminals. Twenty-two percent smaller on the average than previous models, the Strongbox solenoids range in height from $2\frac{41}{64}$ in. to a maximum of $4\frac{21}{64}$ in. This smaller size permits more compact machine design, helps solve space problems.

WIDE RANGE OF RATINGS in both push and pull forms is available. Strongbox solenoids are offered in 9 sizes with 24 basic ratings of 24 to 600 volts, 25 to 60 cycles or direct current.

Nominal ratings in maximum stroke, 60 cycles, are:

½-in. pull from 3.8 to 40 lbs.
1-in. pull from 1.4 to 36 lbs.
½-in. push from 2.5 to 33 lbs.
1-in. push from 4.3 to 28 lbs.
Bulletin GEA-6215 gives details.

NEW general-purpose recorder —with first throw-away inkwell

Now—designers can utilize G.E.'s Type CH Recorder to obtain low-cost, precise measurements. Servicing time and costs are cut because of six new advantages: (1) large, 3-ounce clear-plastic inkwell has three times the ink capacity, reduces problems of open inkwells found in all other recorders; (2) 150-foot record rolls are 1½ times longer; (3) up to 28 different chart speeds—ranging from ¼ in./hr. to 120 in./min.; (4) records are easy to read because of excellent internal lighting and maximum contrast between red ink and light green chart lines; (5) durably built for long life; (6) all necessary work can be done from front of recorder, and there is plenty of working space in white-painted interior of case. Bulletin GEC-1319.

Amplidyne controls voltage, speed, current, power factor, position

General Electric's electronic amplidyne combines a highly responsive amplifier with a regulated power source. From this one unit you get stepless, variable speed control, regenerative braking with current limit, maintenance of speed with overhauling loads, and fast, smooth acceleration or deceleration with protective current limit. These versatile units are installed on the d-c motor feed drive of the Giddings and Lewis boring mill. Check coupon for Bulletin GEA-4053B.

General Electric Co., Apparatus Sales Division, Section B668-129, Schenectady 5, N. Y.

Please send me the following bulletins: √ for reference × for immediate project

☐ GEA-6127 Speed Variators
☐ GEA-4053B Amplidynes
☐ GEC-1319 New General Purpose Recorder
☐ GEA-6215 Solenoids

Name _____ Company _____

City _____ State _____

Dow plastics in action . . .

DOW

You get a better package when you start with a Styron formulation

Plastic containers have helped make these and dozens of other packaged products outstanding sales successes. They were molded from Styron® compounds offering a varied combination of desirable packaging properties*.

This widespread acceptance in the packaging fiel[illegible] just one example of the versatility [illegible] Styron. The jobs of designers and molders in *any* field are made easier by the wide selection of specialized properties available with the different Styron formulations.

Look to Dow when you think of plastics. Behind each Styron molding compound, a broad background of technical research and development stands ready to help you in product development or improvement. For further information or for technical assistance on any polystyrene problem, write THE DOW CHEMICAL COMPANY, Midland, Michigan, Plastics Sales Department PL 431G.

**Can be easily formed from sheet or molded in a wide range of colors and sizes . . . opaque or crystal-clear . . . printable . . . gives product protection in packing, shipping and on display . . . boosts impulse sales . . . adds merchandisability.*

DOW POLYSTYRENE FORMULATIONS:

STYRON 666 . . . Dow general-purpose polystyrene.

STYRON 688 . . . for controlled flow and controlled pressure distribution in the mold cavity.

STYRON 777 . . . for medium-impact strength.

STYRON 475 . . . for high-impact strength and high elongation.

STYRON 475 SHEET . . . for vacuum or pressure forming.

STYRON 480 . . . for extra-high-impact strength.

STYRON 700 . . . for high heat resistance.

you can depend on DOW PLASTICS

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FROM *minnows* TO WHALES

This is a kind of "Mutt & Jeff" portrayal of CORNISH versatility in designing and producing any type and size of Cord Set to YOUR special needs. Leading manufacturers of electrical equipment and appliances no longer gamble . . . they just *CORNISH 'em!* All our technical and physical facilities at YOUR service.

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Custom **CORD SETS**

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50 Church Street New York 7, N. Y.

PowerGrip "Timing®" Belt

"For invention of high order and for particularly meritorious improvements and developments in machines and mechanical processes."

These are The Franklin Institute's words in awarding its 1955 Longstreth Medal to the inventor of U. S. PowerGrip "Timing" Belts—the outstanding contribution to power transmission of the decade.

It's easy to understand why PowerGrip received this great award. By providing near-100% efficiency in positive, non-slip, split-second timing, it has become standard equipment on a wide variety of machines and appliances. The list grows daily.

U. S. PowerGrip Timing Belts—and descriptive literature—are obtainable from factory-trained engineers at any of the 28 strategically located "U. S." District Sales Offices or by contacting us at Rockefeller Center, New York 20, N. Y.

The Franklin Institute, founded in Phila. in 1824, is one of the oldest and most renowned scientific institutions. Its awards are made only after exhaustive studies of contributions to science.

Mechanical Goods Division

United States Rubber

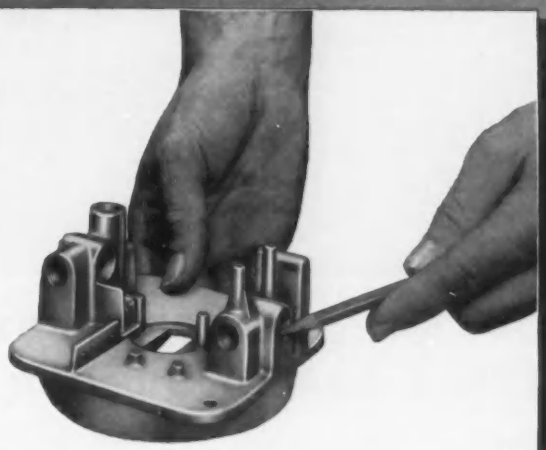
45 years OF SERVICE TO INDUSTRY

It may *look* complex . . . but you couldn't prove it by the cost!

Making this die casting wasn't particularly tricky. But making it in quantity at a low cost *was*. And Stewart did it by devising a setup that performed 24 separate machining operations at one time.

Just one more example of the way Stewart's long die casting experience, plus complete machining facilities, have helped industry.

If *you* have need for a die casting, remember, you can always count on Stewart to meet your most rigid specifications . . . on time.



This emblem is your assurance that the zinc alloy used in every Stewart die casting meets the rigid specifications established by the American Die Casting Institute.

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Stewart DIE CASTING

A DIVISION OF STEWART-WARNER CORPORATION

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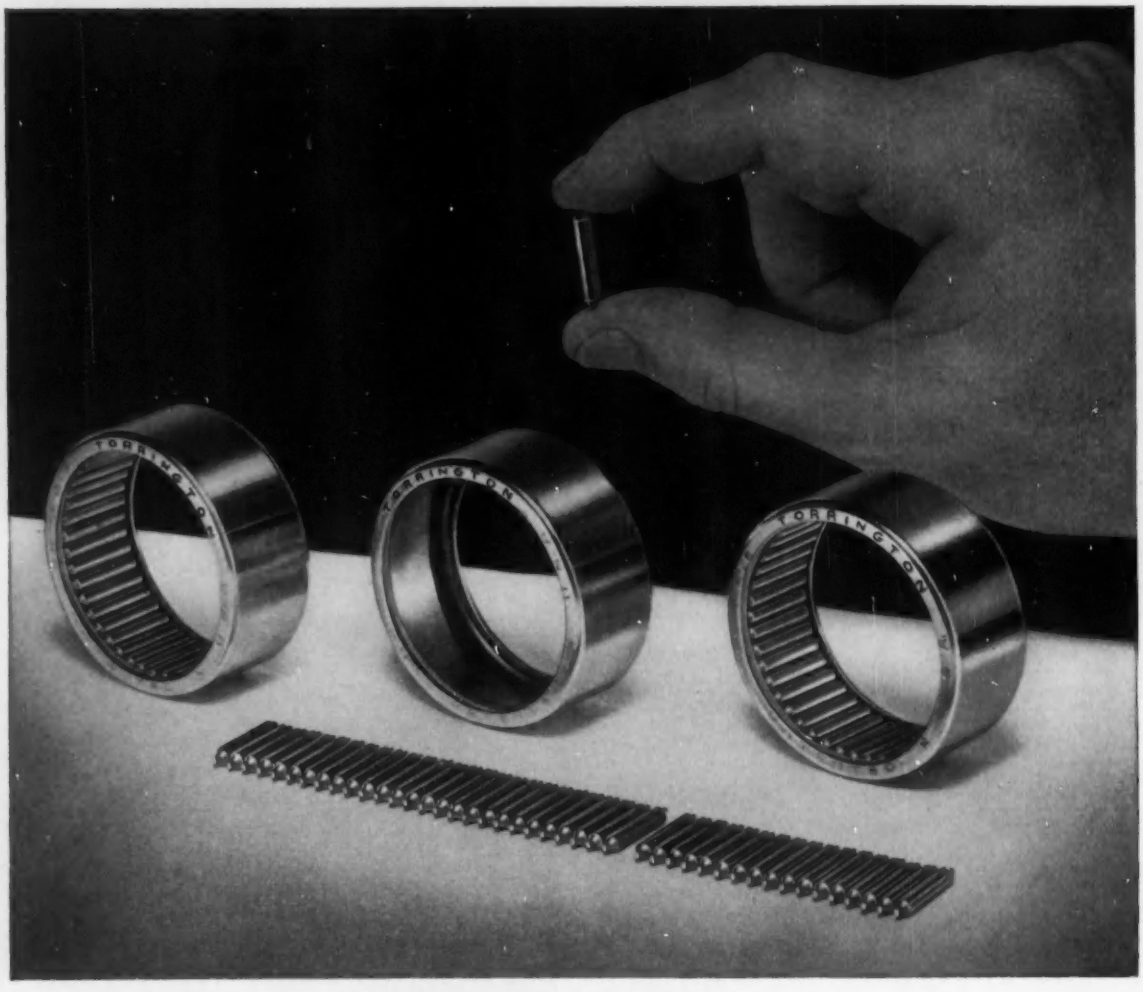


Here's where the **TORRINGTON NEEDLE BEARING** *gets its precision*

This Needle Roller is the "work horse" of the Torrington Needle Bearing. Its jewel-like precision is the key to smooth performance of the Needle Bearing. That's why in every manufacturing step—from alloy selection to final polishing—the rollers are checked against strict quality controls.

A full complement of Needle Rollers, mounted in a precision-made, case-hardened retaining shell, provides a maximum number of contact lines, giving the Torrington Needle Bearing a higher radial load capacity than any other bearing of comparable size.

The Torrington Needle Bearing delivers top anti-friction performance—with low coefficient of both starting and running friction.

For more than twenty years, our Engineering Department has helped designers and manufacturers throughout industry to adapt the unique advantages of the Needle Bearing to their products. Let us help you make the Needle Bearing "standard equipment" in yours.

See our new Needle Bearing Catalog in the 1956 Sweet's Product Design File —or write direct for a catalog.

TORRINGTON NEEDLE BEARINGS
Give you these benefits

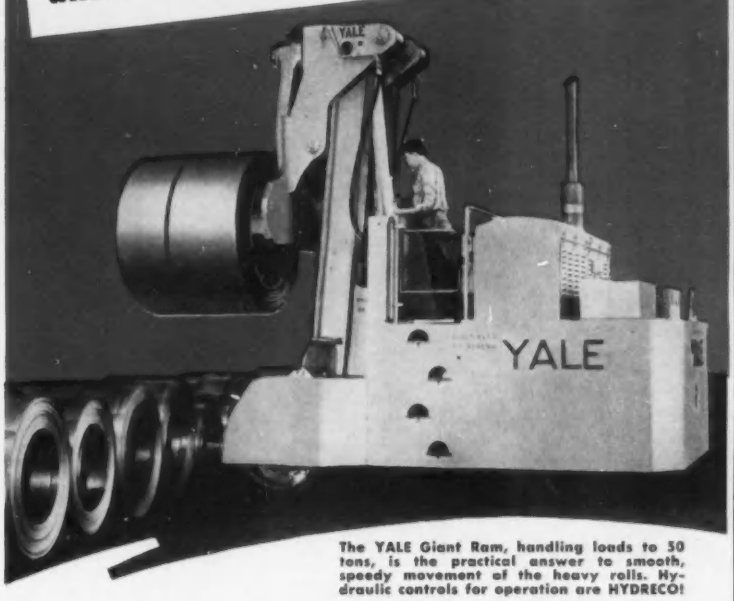
- low coefficient of starting and running friction
- full complement of rollers
- unequalled radial load capacity
- low unit cost
- long service life
- compactness and light weight
- runs directly on hardened shafts
- permit use of larger and stiffer shafts

THE TORRINGTON COMPANY
Torrington, Conn. • South Bend 21, Ind.
District Offices and Distributors in Principal Cities of United States and Canada

TORRINGTON BEARINGS

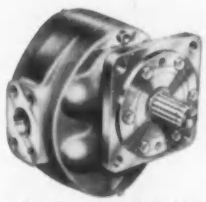
Needle • Spherical Roller • Tapered Roller • Cylindrical Roller • Ball • Needle Rollers

Every Day is Moving Day in a Strip Mill and a Load May Weigh 50 TONS!

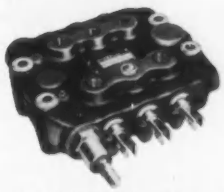


The YALE Giant Ram, handling loads to 50 tons, is the practical answer to smooth, speedy movement of the heavy rolls. Hydraulic controls for operation are HYDRECO!

But, It's Up and Away With a Flip of a Valve with HYDRECO Oil Power



Power for the Hoist Cylinder and adjustable forks of the YALE Giant Ram is furnished by a 3000 Series HYDRECO Pump.



Series V-12 HYDRECO Valve controls the Hoist Cylinder. An auxiliary HYDRECO Valve controls the forks.

The equipment that is "getting things done" today is more often than not equipped with HYDRECO Hydraulic Pumps, Motors, Valves and Cylinders. And, in engineering tomorrow's successful Materials Handling equipment, Farm Machinery, Heavy Construction and Earth Moving vehicles, the one outstanding attribute you will look for in components for the hydraulic system is —DEPENDABILITY. For years, the builders of equipment that "sells and performs" have used HYDRECO Oil Power. And, they have also drawn freely from the well of engineering "know-how" and experience which is here in HYDRECO. All are here for you, too.

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INTERNATIONAL SALES OFFICE, 90 WEST ST., NEW YORK 6, N. Y.

FLUID POWER MULTIPLIES FUNCTIONS IN MATERIALS HANDLING EQUIPMENT

Warehousing and Shipping Costs Cut by Modern Techniques

The great strides in the development of materials handling equipment in the past decade have contributed economic advantages of far reaching importance. Speeding the stocking and withdrawal of finished goods for shipment reduces inventory requirements as well as paring waiting time of trucks and other transport facilities to a minimum. From rough raw material to bulk or packaged finished products, modern lift trucks and conveying systems are cutting costs very markedly.

Fluid Power, with its ability to deliver power in any direction and around obstacles without complicated linkages, cams, gears or levers, has been the vital ingredient in the materials handling picture. Lift trucks that are arranged to clasp a barrel, box or odd-shaped casting... move the article wherever desired... pack prodigious amounts of work into fewer man hours.

HYDRECO Gear Pumps and Motors, Valves and Cylinders have contributed importantly to the development of today's versatile lift trucks. The roster of famous makes using HYDRECO Fluid Power components... from the smallest to largest ...reads like "Who's Who in Materials Handling."

DUDCO Dual-Vane Pumps and Motors are particularly significant in the development of conveyor systems to ideally suit specific needs. Their ability to deliver 2000 psi for continuous operation finds application in such diversified services as moving pineapples, strawberries and other food products, as well as ceramic moulds, powdered chemicals and a long list of other light and heavy materials.

Catalogs of HYDRECO and DUDCO components and the assistance of an engineer experienced in solving materials handling problems are available without obligation.

Kalamazoo Division
The New York Air Brake Company
9012-5 E. Michigan
Kalamazoo, Mich.

Gentlemen:

I am interested in receiving literature on

☐ HYDRECO 1000/1500 psi components
☐ DUDCO 2000 psi Dual-Vane Pumps and Motors

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Company_____
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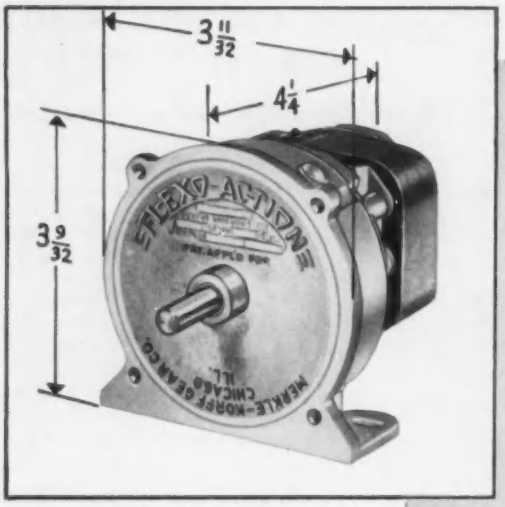
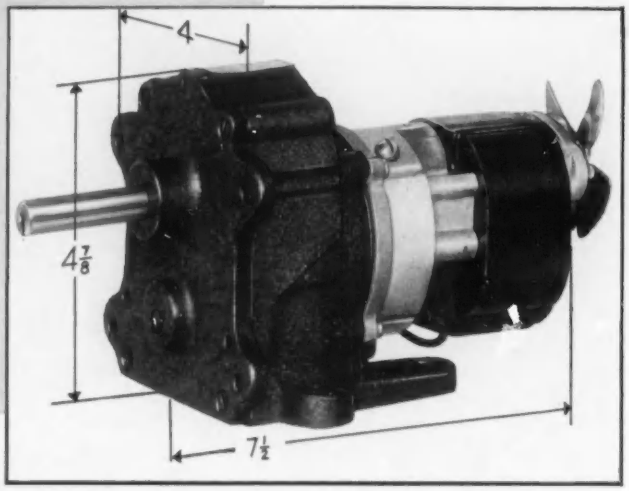
POWER UNDER CONTROL



This fhp geared motor will produce 30 pounds inch torque at 30 RPM.



This fhp geared motor will produce 300 pounds inch torque at 3 RPM.

News for users of low speed high torque drives

Speeds from about 800 RPM down to any fractional RPM.

Torque from a few ounces to over 300 lb. in.

Practically unlimited number of mounting arrangements.

This great flexibility in Merkle- Korff fhp geared motors eliminates many design problems when incorporating these drives in your product or process.

Merkle-Korff motors may be induction, synchonous, series or shunt wound—either uni-directional or reversing. They are 1/20th h.p. and under.

The sealed case contains precision cut gears and pinions. All steel gears are heat-treated.

These top quality units are built to give many years of service for either continuous or intermittent duty. Hundreds of thousands of Merkle-Korff geared motors are in service today in vending machines, photo copy equipment, pumps, sequence timers, valve operators and a wide range of other industrial applications.

Merkle-Korff design engineers are available to assist your staff in providing a drive unit with the right speed and torque for the job.

Detailed dimension drawings and torque tables are available in a guide for the selection of fractional horse power geared motors. Ask for bulletin PE-1.

Some applications of Merkle-Korff drives will be demonstrated at the Design Engineering Show. See them in Booths 415-19.

MERKLE-KORFF GEAR CO.

219 NORTH MORGAN STREET • CHICAGO 7 • ILLINOIS

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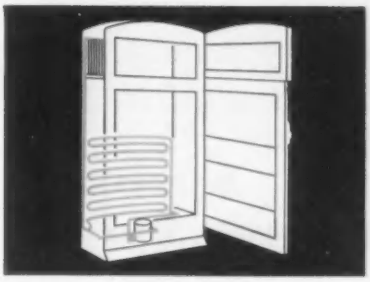
BOGGED DOWN BY TUBING PROBLEMS?

Let Rochester pull you out! Our engineers and specialists step in to help you with every phase of your production. They assure top quality steel tubing, and often find ways to pare costs and fatten profits. What's more, GM Steel Tubing's on-schedule delivery eliminates costly production snarls.
GM Steel Tubing is rugged, reliable, flexible, versatile—designed to take it and take any shape. You'll find it knuckling down for long, trouble-free service on more cars—more refrigerators and freezers—more advanced products every day. Contact your Rochester Products Engineer, or write us direct for further information.



GM STEEL TUBING BY ROCHESTER PRODUCTS

ROCHESTER
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DIVISION OF
GENERAL MOTORS
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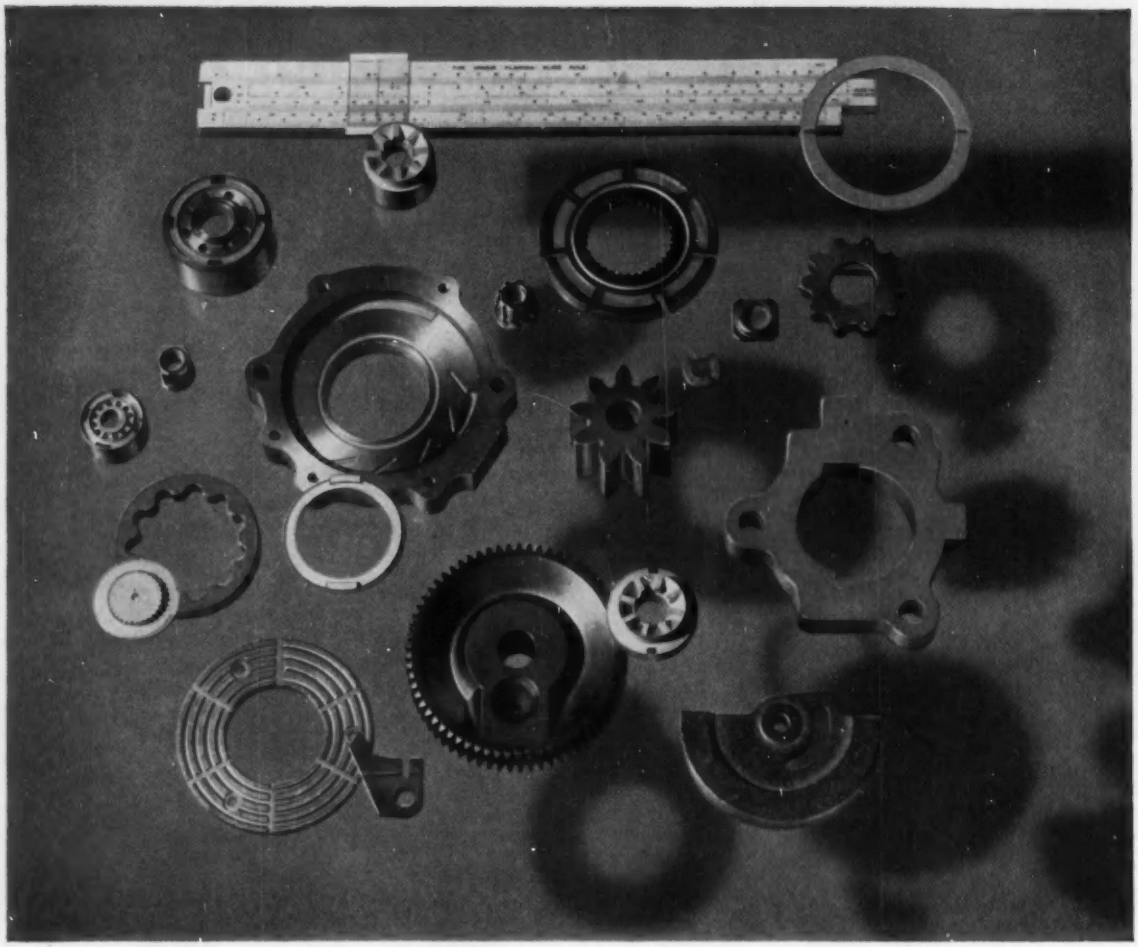


A look at your needs . . . through the eyes of our experiences

You are looking at a typical group of precision parts each of which is being produced in large quantities by Moraine Products from metal powder. When you note the wide variation in shapes and sizes, you will realize each part was designed for a specific application.

What may not be obvious is the fact that, when Moraine Products is asked to produce parts like these, each part is carefully weighed in these terms: What will it be asked to do for the end product of which it will become a component?

Because we purchase or manufacture—for our own use, in our own plant—parts made by stamping, screw machine, forging, cold-heading, molding, and casting, we are familiar with a wide range of processes commonly used in industry. Consequently, our judgment can be considered realistic when we recommend metal powder and powder metallurgy as the material and the process best suited for a specific part.

Other Moraine products include: Moraine power brakes — Delco hydraulic brake fluids, brake assemblies, master cylinders, wheel cylinders and parts—Moraine friction materials —porous metal parts—rolled bronze and bi-metal bushings—self-lubricating bearings, and automotive engine bearings.

Another General Motors Value

Moraine Products

Division of General Motors, Dayton, Ohio

Dempster-Dumpster—a truck-mounted fork lift designed to handle trash and other bulk materials, shown in dumping position. INSET: "Dacron" is the reinforcement in the V-belts on the 13-inch, 2-groove drive—increasing delivered horsepower, efficiency of hydraulic pump.

How the Dempster-Dumpster's V-belt drive efficiency was increased by premium V-belts reinforced with DACRON

REG. U.S. PAT. OFF.

The lifting and steering power of the Dempster-Dumpster generates from a single hydraulic pump driven by V-belts. To insure dependable, slip-free operation and positive starting at this important spot, Dempster Brothers, Inc., switched to premium V-belts reinforced with Du Pont "Dacron"* polyester fiber. During the six years since the change, the belts have been proving their superiority on hundreds of Dempster-Dumpsters in use throughout the country.

Slippage and stretching have been sharply reduced by the 40% greater strength of belts made with Du Pont "Dacron". Two premium V-belts now do the work formerly handled by three standard belts. The belts remain stable . . . deliver more horsepower from the pump. And the ability of these belts to withstand greater shock loading assures fewer replacements, more efficient, trouble-free operation.

In designing *your* next drive, investigate the advantages of premium V-belts made with "Dacron". They combine the unique properties of the "Dacron" yarn made by Du Pont and the highest skills of the leading V-belt manufacturers. For a list of manufacturers using "Dacron" in premium V-belts, write to E. I. du Pont de Nemours & Co. (Inc.), Textile Fibers Dept., Wilmington 98, Delaware. Premium V-belts shown in above photo were manufactured by the U.S. Rubber Company.

6 REASONS FOR USING PREMIUM V-BELTS REINFORCED WITH "DACRON"

- Transmit up to 40% more horsepower.
- Withstand greater shock loading.
- Longer flex life.
- Cut downtime.
- Low stretch.
- Require less maintenance.

***"Dacron"** in V-Belts* DU PONT

REG. U. S. PAT. OFF.

**"Dacron" is Du Pont's registered trademark for its polyester fiber.*

BETTER THINGS FOR BETTER LIVING . . . THROUGH CHEMISTRY

Your Design Problems

PROBLEM: Lay Out Piping Most Economically

PROBLEM: Adapt One Pump to All Units

PROBLEM: Stocking Too Many Models

PROBLEM: Mounting Method Restrictions

SOLVED

by ALLIS-CHALMERS Pump Specialists

Your Allis-Chalmers representative is an experienced, highly qualified pump specialist who will give you full cooperation — from planning to purchasing to production. He will help you select exactly the right pump to fit your requirements from Allis-Chalmers wide range of types and sizes.

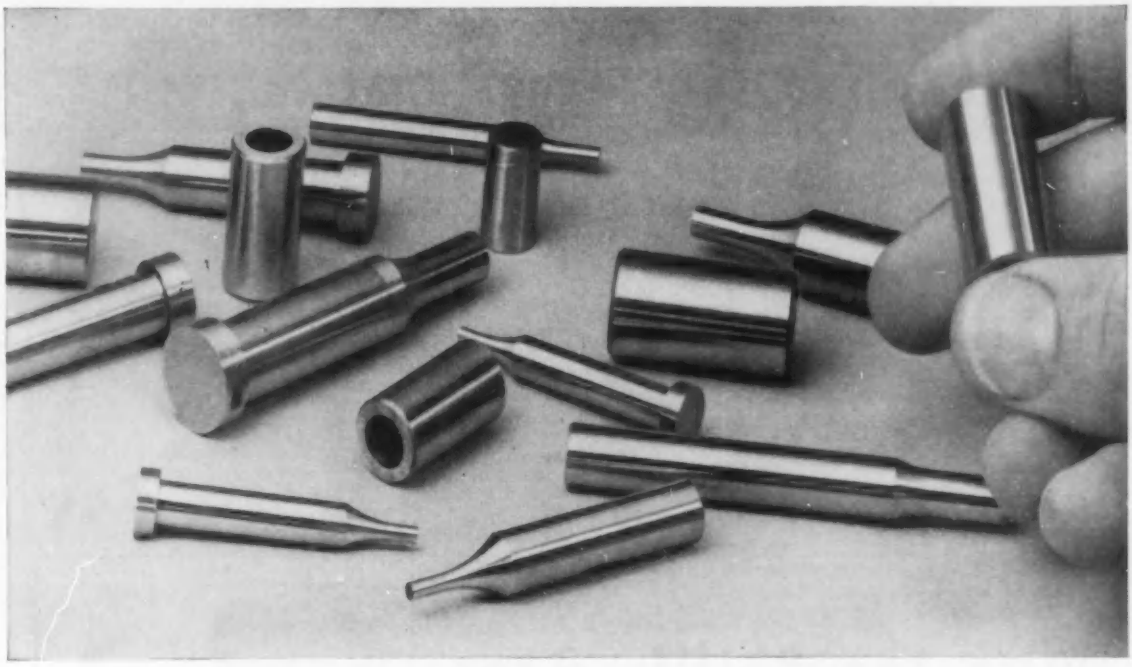
The A-C expert will gladly give you as much help as you need in engineering your setup. He may be able to make valuable suggestions which will result in savings of time, money, effort, or in a better product.

Once your equipment goes into the field, Allis-Chalmers nationwide network of Certified Service Shops assures fast service wherever the user may be, relieving you of part of your service problem.

Allis-Chalmers OEM pumps are available from strategic stocking points all over the country. Contact your A-C District Office for details on how to expedite pump selection and ordering, or write Allis-Chalmers, Milwaukee 1, Wis., for more information.

A-4753

ALLIS-CHALMERS



How the country's largest exclusive producer of punches and dies changed complaints to contracts

. . . with Graph-Mo® steel

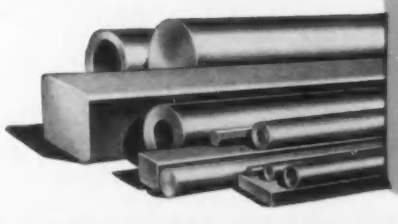
PORTER Precision Products, Cincinnati, Ohio, is the country's largest exclusive manufacturer of punches and dies—37,000 different sizes in stock. Formerly, Porter produced these products from water-hardening and other high-carbon tool steels, but found that such steels presented distinct disadvantages. For example, they distorted in heat treating, were relatively expensive and difficult to machine, and did not meet customers' demands for longer life.

With a view to correcting these problems, Porter engineers adopted Graph-Mo®—one of four graphitic tool steels developed by the Timken Company—as a standard for the manufacture of punches and die buttons. Because it contains free graphite, Graph-Mo is easier to machine. And punches and dies made of Graph-Mo don't scuff or gall. From every aspect, Porter's adoption of Graph-Mo steel has proved eminently successful.

Graph-Mo outwears ordinary tool steels on an average of three to one. Millions of tiny particles of diamond-hard carbide—one of the most wear-resistant substances known—give Graph-Mo steel longer service life.

Graph-Mo may be the solution to *your* punch and die problems. For more information about all four graphitic steels developed by the Timken Company, and their uses in dies, punches, gages, and machine parts, write for the new Timken Graphitic Steel Data Book. The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO".

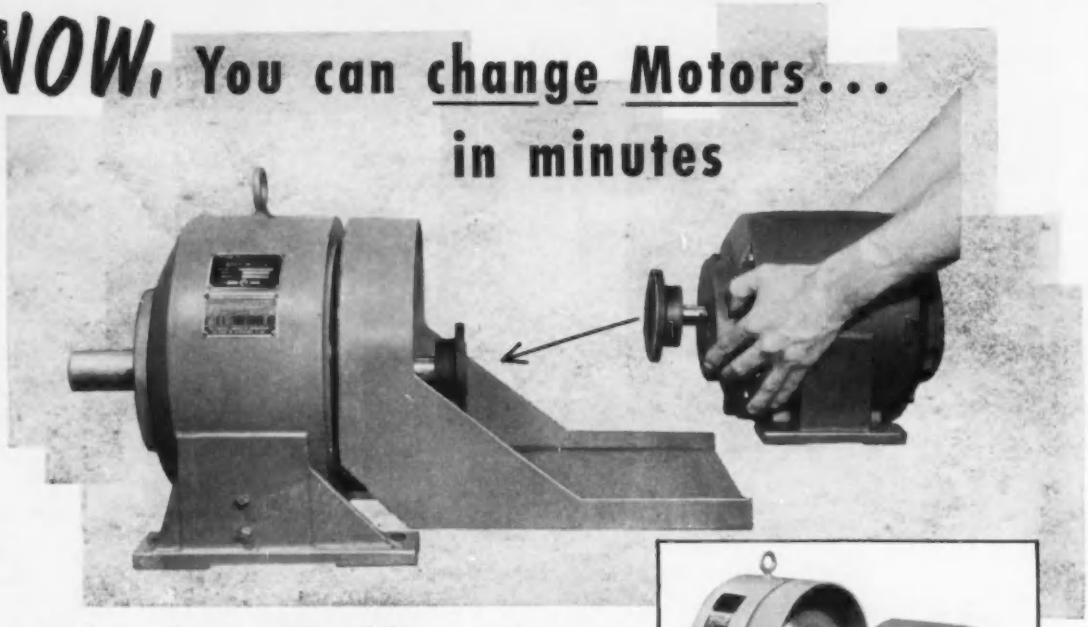
YEARS AHEAD—THROUGH EXPERIENCE AND RESEARCH

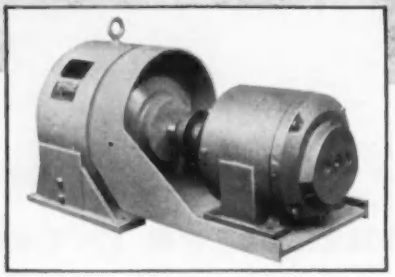


TIMKEN
Fine Alloy
STEEL

SPECIALISTS IN FINE ALLOY STEELS, GRAPHITIC TOOL STEELS AND SEAMLESS TUBING

NOW, You can change Motors... in minutes





with the Phillie Gear utility GEARMOTOR

Motors can be interchanged or replaced in a matter of minutes, merely by unbolting the old motor, separating the coupling halves, and bolting-on the new motor. *No long and costly "down-time".* Replacement of standard foot mounted motors is not limited to the original make of motor.

The Philadelphia Utility GearMotoR is of heavy, non-corrosive cast iron construction. The rugged design of the motor support eliminates alignment and vibration problems between reducer and motor. The Helical gearing is heat-treated alloy steel, precision cut and shaved after heat treatment, in order to eliminate possibility of distortion; Shafting is of the highest quality, and antifriction bearings are used throughout; Lubrication is by the dip and splash method which requires minimum attention and helps to assure quiet operation and long service life. Remember, the Utility GearMotoR, like all other Phillie Gear Speed Reducers, is the result of over 63 years continuous experience.

These units are available with motors up to 60 h.p., in full range of AGMA output speeds—they can be furnished from stock for prompt delivery, either with or without motors. The Utility GearMotoR is equipped with the patented and widely used Philadelphia "Sphereflex" Flexible Coupling, which provides additional versatility of mounting. Send for complete new 48 page GearMotoR Catalog, on your business letterhead.

phillie gear®

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ERIE AVE. & G STREET, PHILADELPHIA 34, PENNA.
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INDUSTRIAL GEARS & SPEED REDUCERS • LIMITORQUE VALVE CONTROLS • FLUID AGITATORS • FLEXIBLE COUPLINGS
Virginia Gear & Machine Corp. • Lynchburg, Va.

Perspectives

IN DESIGN AND DEVELOPMENT

THE STATUS OF MISSILES

Over the past decade, the military services have invested about $6-billion to design, test, and produce guided missiles. But only in the past two years have these weapons started coming out of the laboratory and into the hands of the troops in operational quantities. The three military services have about 40 missile projects under way, which range in type from the air-to-underwater to the 5000 mile Intercontinental Ballistic Missile (ICBM). In status, they range from initial research, like anti-missile missiles, to heavy volume production and operational use.

For many tactical missions, the guided missile is starting to displace conventional anti-aircraft and field artillery, naval guns, and aircraft armament. But total push-button warfare, where defense surface-to-air missiles would knock out ICBMs, is not just around the corner. The guided missile is still pretty much in its infancy, and none has been tested in a true operational sense.

THE MISSILES WE HAVE

For an emergency, the U. S. now has operation missiles consisting of:

· The Army's *Nike,* a one-ton, anti-aircraft missile produced by Western Electric and Douglas Aircraft. Guided by radar, and traveling at speeds of Mach 2, the missile is designed to hit enemy planes within a range of 25 miles, regardless of any evasive tactics. It is launched by a solid-propellant rocket booster, which is jettisoned, after which a liquid-propellant rocket takes over.

· The Navy's *Terrier,* a ship-launched anti-aircraft missile with a range of about 20 miles, is being produced by the Convair Division of General Dynamics Corp. Like the Nike, it is launched by a solid-propellant rocket, then its liquid-propellant rocket motor takes over.

· The Navy's *Sparrow,* a small air-to-air missile produced by Sperry Gyroscope Co., and Douglas Aircraft, for carrier-based jet fighters, is powered by a solid-propellant rocket, and hits speeds of Mach 3.

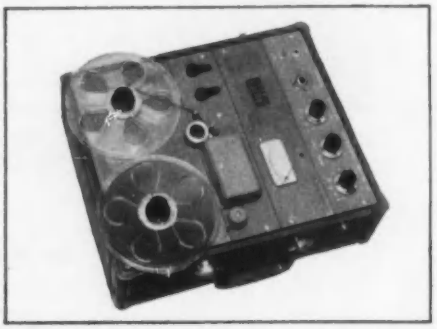
· The Air Force's *Falcon,* a 100 lb missile carried by land-based aircraft has a 5-mile range. Produced by Hughes Aircraft, it is the latest missile to become operational.

· The Army's *Corporal,* designed by the California Institute of Technology and produced by Firestone Tire and Rubber Co., is a huge missile (40 ft long, weighing 12,000 lb) that fires a nuclear warhead up to 50 miles. It is powered by a liquid-propellant rocket, and has a guidance system precise enough to hit concentrated tactical targets.

· The Navy's *Regulus,* 2500 lb heavier than the Corporal, and almost twice its diameter, is fired from surfaced submarines and ships against land targets. Produced by Chance Vought Aircraft, it looks like a conventional swept-wing jet fighter. It is a two-stage missile—launched by two solid-propellant rockets, and powered by a turbojet engine. An im-

(Continued on page 131)

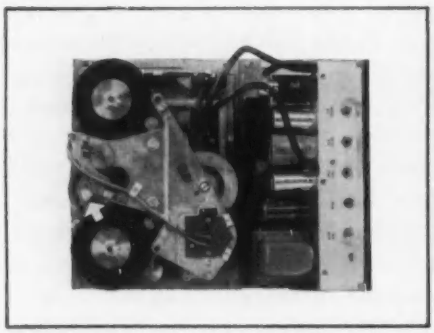
Why Bodine motors were selected for Ampex Tape Recorders



1 This is a new portable 28-pound Ampex 600 professional tape recorder. It is ideal for broadcast studios and music schools.

2 Studio engineers use the Ampex 600 for broadcast recording, line recording, dubbing and editing, and broadcast playback.

3 The frequency response of the Ampex 600 is 40 to 15,000 cps; signal-to-noise ratio is over 55 db.; flutter and waw under 0.25%.



4 Supplying power for the capstan drive, plus take-up and rewind operations, is a Bodine Type KYC-41, capacitor, synchronous motor

5 Meet Mr. John Leslie, Chief Engineer, Audio Division, Ampex Corp., Redwood City, Calif., manufacturers of Ampex tape recorders.

"Bodine motors have proven themselves over a period of years to be excellent as to both reliability and performance. Bodine's quality of workmanship provides us with smooth running, trouble-free motors whose torque characteristics are uniform from motor to motor."

6 Mr. Leslie relates why Bodine motors were selected to meet his company's very exacting requirements...see above.

7 Be sure your motor is as good as your product. For information contact Bodine Electric Co., 2260 West Ohio Street, Chicago, Illinois.

BODINE MANUFACTURES FRACTIONAL HORSEPOWER ELECTRIC MOTORS FOR:

adding machines
letter openers
sanders
vending machines
exhaust fans
duplicating machines
portable tools
sound recorders
air conditioners
check protectors
respirators
voltage regulators
x-ray timers
traffic signal timers
stirrers
calculating machines
envelope sealers
diesel governors

. . . and for many other applications.

Ask for a sample copy of "The Motorgram," a bi-monthly publication discussing application and design of fractional horsepower electric motors.

Perspectives

· The Air Force's *Matador,* produced by Glenn L. Martin, is a surface-to-surface missile that takes off from a fixed launcher with a one-rocket booster that puts it on its course. With a motor similar to the Regulus, its range is up to 600 miles at supersonic speeds.

· The Army's *Honest John,* produced by Douglas Aircraft, is an unguided surface-to-surface missile with a range of long-range artillery.

· The Navy's *Petrel,* a mach 0.7, air-to-underwater missile.

Backing up these missiles are several others just coming into production: (1) The Air Force's *Rascal,* an air-to-surface missile produced by Bell Aircraft; (2) the Navy's surface-to-air *Talos,* with a range far beyond the Nike and Terrier, produced by McDonnell Aircraft; (3) the Army's *Redstone,* a 250 mile tactical ballistic missile produced by Chrysler Corp.

INTER-SERVICE RIVALRY

The Defense Dept. recently announced that the Air Force will set up Talos missile sites to provide anti-aircraft defense for four of its strategic air command bases. This action showed up the inter-service squabbling which is regarded as the major deterrent to a more rapid missile development program. The Army, who usually provides all anti-aircraft defense with conventional guns and the Nike missile, complains that the Air Force operation of Talos would be an invasion of the Army's work.

Each of the services wants a 1500 mile Intermediate Range Ballistic Missile (IRBM). The Air Force's project is Douglas Aircraft's *Thor,* while the Army and Navy have a joint project at the Redstone Arsenal.

INTERCONTINENTAL BALLISTIC MISSILES

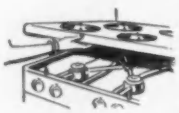
The propulsion problem is about licked in this program. Less advanced is the guidance system. The major difficulty is a nose-cone and warhead which can withstand the temperatures of re-entry into the atmosphere at speeds of 16,000 mph.

Because technology will increase the development time for an operational ICBM, the Air Force is developing slower, and lower flying guided missiles which have intercontinental ranges: (1) Northrop Aircraft's *Snark,* now in prototype, has wings like an airplane and is 32 ft long and $4\frac{1}{2}$ ft in diameter. Propulsion is by a single jet of at least 10,000 lb thrust, giving a speed of 600 mph at 40,000 ft. Just last month it was reported that the Snark flew 2000 miles out into the central Atlantic Ocean. The test was more one of range than accuracy; (2) North American's *Navaho,* still in the research stage, will fly at about Mach 2.5 at around 75,000 feet. Larger than the Snark, a rocket booster will get it into the air where a ramjet engine will take over.

SPECIAL ASSISTANT FOR MISSILES

To control this ever-expanding program, presently $1.5-billion annually, Defense Secretary Wilson recently named Eger V. Murphree, Pres. of Esso Research and Engineering Co., to be his special assistant for guided missiles. The job is to direct and coordinate all research, development, engineering and production. His appointment is the result of a charge that there was no Pentagon official on a secretary or near-secretary level who spent full time on missile work.

Blind attachments made at 82% lower cost ...with Tinnerman SPEED CLIPS®!



Automatic Range Company, Brooklyn, cut assembly costs on its Royal Rose Ranges 82% with a Tinnerman tubular-type SPEED CLIP®. It locks the removable range tops securely in place. Automatic Range designers were able to eliminate a costly bracket, a wire form catch and a spot welding operation with this engineered fastener.

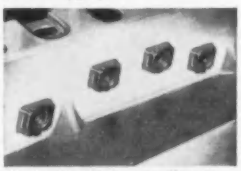
One-piece, spring-steel SPEED CLIPS are quickly and easily snapped into punched holes in the range's top. Self-retained, the SPEED CLIP grips the mating stud in the front panel flange with pin-point accuracy under live spring tension for a firm, vibration-proof attachment. Yet the top is readily raised or removed for cleaning or servicing . . . no tools required!

Tinnerman produces more than 8,000 different types and sizes of SPEED NUT brand fasteners. They are designed to help you make faster, easier, more efficient attachments at substantial assembly savings. Consult your Tinnerman representative for complete information on standard or specially engineered SPEED NUTS. Also write for your copy of "SPEED NUT Savings Stories."

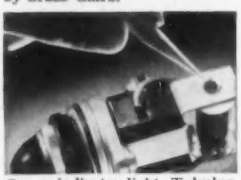
TINNERMAN PRODUCTS, INC. • BOX 6688, DEPT. 12, CLEVELAND 1, OHIO

Canada: Dominion Fasteners, Limited, Hamilton, Ontario. *Great Britain:* Simmonds Aerocessories, Limited, Treforest, Wales. *France:* Aerocessoires Simmonds, S. A., 7 rue Henri Barbusse, Levallois (Seine). *Germany:* Hans Sickinger GmbH "MECANO", Lemgo-i-Lippe.

In a heating-unit assembly, "J" type SPEED NUTS eliminate problems of hole misalignment and paint clogging.



On truck radiators, costly retapping of flash-clogged threads of weld-type fasteners is eliminated by SPEED GRIPS.

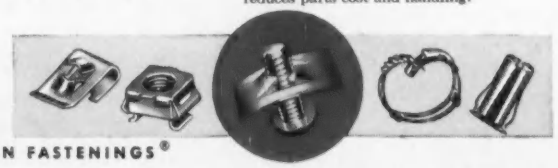


On an indicator light, Tubular SPEED CLIP replaces 4 parts, reduces parts cost and handling.

TINNERMAN

Speed Nuts

FASTEST THING IN FASTENINGS®



A Two-Way Service

In 1914 there was little to differentiate between the designing abilities of a master mechanic, a shop superintendent and a design engineer. To be sure, in a few industries, the designers had to have an unusual fund of design knowledge, as measured in that day. But in many manufacturing plants there was little to differentiate the design engineer from the practical shopman.

All this was natural. The fund of scientific knowledge relating to engineering design was extremely limited, as was the variety of materials available. Electrical components were largely limited to conventional general purpose motors and their starting switches. Hydraulics applied to machinery was practically unknown.

The period from 1914 to 1930 introduced data on fatigue failures, experimental stress analysis, the hydraulic operation of machinery, built-in electrical equipment, and a few synthetic materials.

Not until late 1929 did advertising managers and advertising agency men hear about the important part played by design engineers in the specification of parts, materials and components selected by the design engineer.

Since the beginning of the thirties, engineering design developed in leaps and bounds. The vast family of plastics and a host of other nonmetallic materials including ceramics and various forms of glass, have come into existence. Electronics applied to the control of machinery has become commonplace. Aluminum, magnesium, titanium, tantalum and many other metals have found their way into commercial use. Fluid power has become commonplace.

Today design engineering is a profession that requires a great fund of scientific knowledge. It also requires a firsthand knowledge of the very latest in materials, components and parts available for application to the design of machinery.

In 1945, largely because of an editorial published in Product Engineering, the American Society of Mechanical Engineers organized what has become the Machine Design Division of the A.S.M.E. This was the first recognition by a national engineering society of the transcending importance of the design function in industry. Thus did the profession of engineering recognize the status of the designer.

This month, May 14, 15, 16 and 17, there will be held in Convention Hall, Philadelphia, the first commercial exposition of parts, materials and components that are available for specification by the design engineers. This exposition might be termed as the first national recognition by industry of the commercial importance of the design engineer. It is industry's acknowledgment of the essential part played by the designer in the selection of parts, materials and components. It is also a distinct service rendered by industry to the design engineer. It gives him the opportunity to obtain full and firsthand information concerning the things that industry has to offer the designer to assist him in creating the optimum design of the products on the drawing boards.

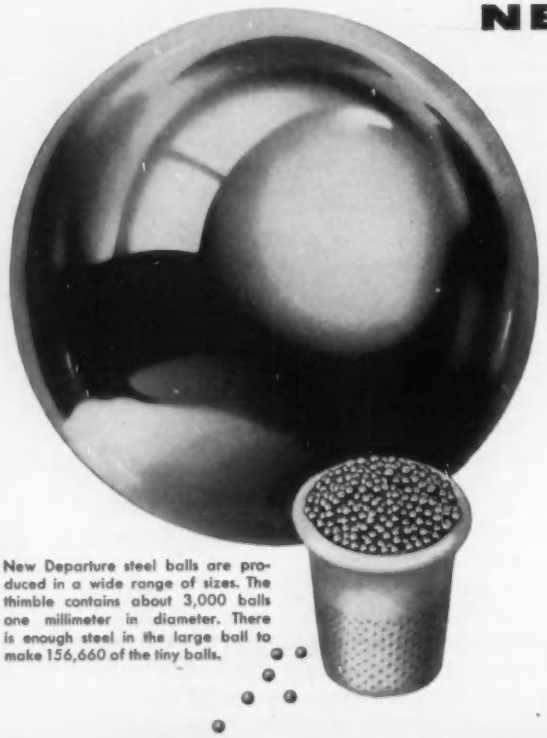
George T. Hookenholt

FACTS

about

NEW DEPARTURE

STEEL BALLS



New Departure steel balls are produced in a wide range of sizes. The thimble contains about 3,000 balls one millimeter in diameter. There is enough steel in the large ball to make 156,660 of the tiny balls.

Available in any quantity to fit your specifications for grade, size and accuracy!

When industry wants steel balls of proven accuracy and dependability, it is only natural that they turn to New Departure, leading producer of ball bearings and therefore thoroughly experienced in the manufacture of precision balls. Today, New Departure provides industry with high-carbon chrome and stainless steel balls in a wide range of sizes and specifications.

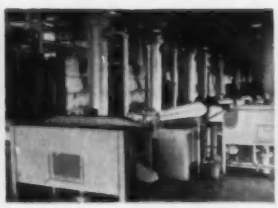
New Departure balls are produced from the finest high-carbon chrome steel. AISI Type E51100 steel, specially made for New Departure, is heat-treated to achieve the proper hardness and toughness for maximum strength and life in the finished product. Stainless steel, AISI Type 440C, used by New Departure results in balls of much improved hardness and load-carrying ability.

In addition to producing the finest steel balls available, New Departure will fill volume orders for balls of special materials such as high-nickel or cobalt-base alloys, tool steel and others.

NEW DEPARTURE • DIVISION OF GENERAL MOTORS • BRISTOL, CONN.

Steel ball wire is drawn through dies to assure uniform diameter and roundness.

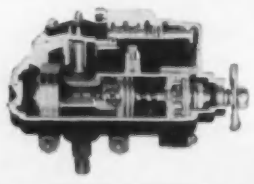
Precise control of grain flow is obtained with these Ball Heading Machines.



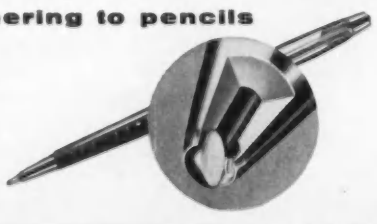
Balls are heat-treated, quenched in oil or water, then tempered in electric furnaces.

These gauges sort balls into lots according to required diameter limits.

Applications range from power steering to pencils



The unique advantages of New Departure steel balls are utilized in many applications ranging from heavy-duty bearings to the new liquid lead pencil. To accommodate these applications, New Departure steel balls are offered in sizes ranging from .025 inch to 1⅞ inches in diameter.



Mechanical properties, fabrication characteristics and potential applications of alloys having the unusual combination of high tensile strength and high damping capacity.

Manganese-Copper High-Damping Alloys

J. W. JENSEN
Physicist, Bureau of Mines

J. A. ROWLAND, JR.
Chief, Branch of Metallurgy, Bureau of Mines

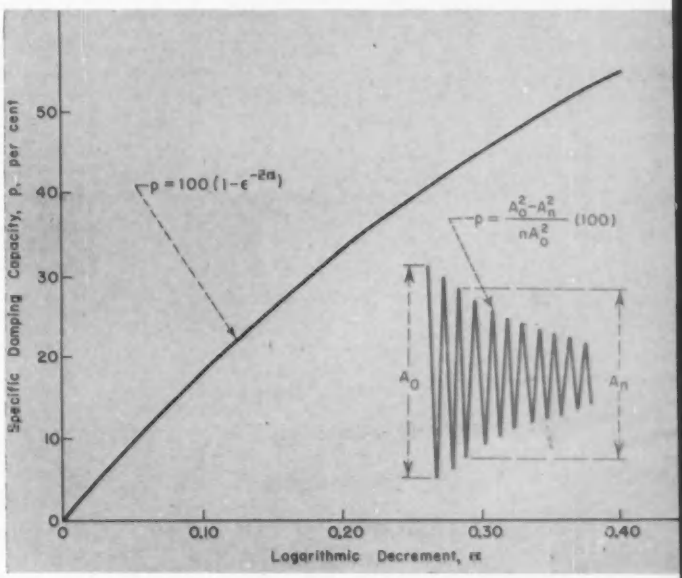


Fig. 1—Amplitudes in lower corner illustrate how the specific damping capacity p can be calculated from measurements of successive amplitudes, A_0 and A_n. A more sensitive term than the specific damping capacity is the logarithmic decrement α. Relation between p and α is given by the curve.

SPECIFIC DAMPING CAPACITY of a material is the per cent vibrational energy absorbed by a test specimen in one cycle, as indicated in Fig. 1. Thus, a metal with a high damping capacity can absorb the energy of resonant vibrations and drastically reduced noise and internal stress.

Manganese-copper alloys have the unusual combination of high damping capacity and high tensile strength. They are comparable to mild steel in strength; but the damping capacity is as different as the sound produced by striking a bell and a lead bucket.

Some of the more important mechanical properties of typical Mn-Cu alloys in comparison with gray cast iron and steel are shown in Table I. Although the relatively high damping capacity of cast iron is one of its useful characteristics, manganese-copper surpasses cast iron in both damping capacity and tensile strength by more than four times. In addition, manganese-copper has excellent ductility while cast iron has very little. However, Mn-Cu alloys are considerably more expensive than cast iron and are available only in the wrought form. The new manganese-copper alloys, therefore, cannot be considered competitive with cast iron but must be evaluated as new materials especially suited to applications where the harmful effects of vibration and noise must be reduced.

Strength, ductility and hardness of the new alloys differ very little from normalized mild steel. In damping properties, however, steel has a logarithmic decrement (a more sensitive term than the specific damping capacity—see Fig. 1) of less than 0.0002 at 5,000 psi in torsional vibration, while the Mn-Cu alloys have a logarithmic decrement of over 0.2—higher by a factor of 1,000.

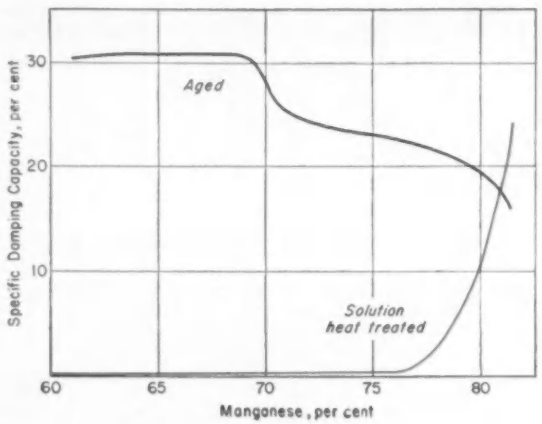


Fig. 2—Specific damping capacity of manganese-copper alloys under 5000 psi load aged 2 hr at 450 C (black) and in solid solution (red).

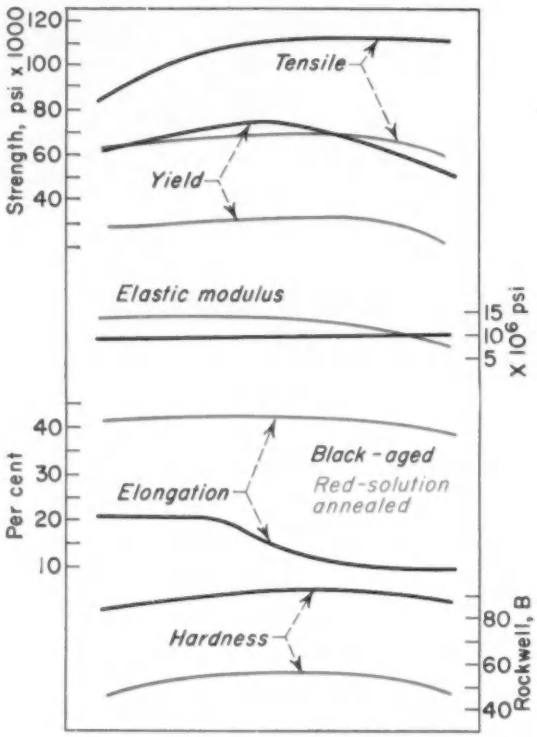


Fig. 3—Mechanical properties of manganese-copper alloys aged 2 hr at 450 C (black curves), and solution annealed (red curves).

Cold-working a material reduces its damping capacity; preloading increases the damping capacity. For example, pure nickel after annealing at 750 C has a very high damping capacity that is reduced abruptly to a very low value with a slight degree of cold-working. Damping capacity of lead is extremely high, but its low resistance to plastic deformation (the principal source of damping capacity of lead) limits its usefulness. Referring again to Table I, the damping capacity of Mn-Cu alloys increases with an increase in induced stress.

Other properties of interest of the new alloys are high electrical resistivity ranging from 120 to 140 microhm-centimeters, and high thermal coefficient of expansion, approximating that of aluminum. On the debit side, manganese-copper alloys age at temperatures above 300 C and have a reduced damping capacity when used above 150 C.

Fabrication Characteristics

Practical methods for fabricating Mn-Cu copper alloys have recently been developed by the U. S. Bureau of Mines in cooperation with the U. S. Navy Bureau of Ships. Details are described in "Casting and Fabrication of High-Damping Manganese-Copper Alloys," by J. A. Rowland, C. E. Armantrout and D. F. Walsh, *U. S. Bureau of Mines Reports of Investigations* 5127, April 1955.

The report indicates that the alloys have a low thermal conductivity, low emissivity, high thermal expansion, high solidification shrinkage, and a narrow freezing

Table I—Specific damping capacity and mechanical properties of manganese-copper, steel, and cast iron.

Material	Condition	Specific damping capacity in per cent at		Tensile Strength, psi	Yield Strength, psi	Elongation % in 2 in.	Hardness, Rockwell "B" scale
		1000 psi	5000 psi				
62Mn-38Cu	Aged at 450 C.	12	32	90,000	60,000	25	90
70Mn-30Cu	Aged at 450 C.	9	28	95,000	70,000	20	90
80Mn-20Cu	Aged at 450 C.	7	23	100,000	55,000	20	90
Gray Cast Iron 3.5% C.	As cast	3	7	20,000	———	<1	85
Gray Cast Iron 3.5% C.	As cast—Machined	4	8	20,000	———	<1	85
Mild Steel	Normalized	<0.1	<0.1	90,000	50,000	25	90

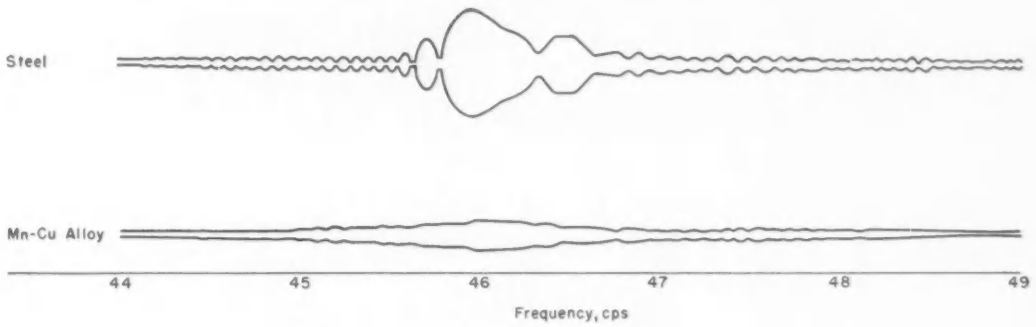
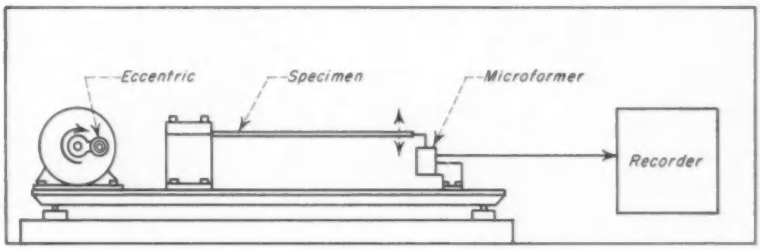


Fig. 4—Vibration amplitudes of steel (upper) and manganese-copper (lower) cantilever beams excited by a rotating eccentric. Frequency range shown includes the resonance frequency of beam. Damping capacity of manganese-copper beam decreases amplitudes at resonant frequencies.



range. This causes primary and secondary piping when the alloys are cast in conventional molds. Chemical activity of manganese also causes entrapment of oxides in the molten stage. Successful casting requires use of deoxidizers, proper mold design and pouring temperatures.

Although most impurities can be tolerated to a considerable extent, carbon has a detrimental effect on the mechanical properties. Therefore, electrolytic manganese and wire or bar copper are generally used for the charge.

Manganese-copper alloys are not readily cast to shape. They are generally hot-worked to the desired size and then machined to final dimensions. Hot-working also insures homogeneity. The alloys can be hot- or cold-worked by impact or press forgings, rolling or swaging.

Optimum properties are produced by heat treating the wrought alloys to 700-850 C long enough to obtain uniform solid solution without excessive grain growth (see Metals Handbook, *American Society for Metals*, 1948 page 1198). This is followed by aging at 375 to 500 C to cause nucleation and growth of alpha manganese, resulting in high damping capacity and improved mechanical properties. As seen in Figs. 2 and 3, a considerable range of characteristics can be obtained by varying the composition and heat treatment, with total ranges approximately as follows: Tensile strength: 65,000-105,000 psi; yield strength: 25,000-70,000 psi; elongation: 10-40 per cent; modulus of elasticity: 8-11 x 10^6 psi; hardness: 50-92 R_B; specific damping capacity: 0.1-30 per cent at 5,000 psi.

Potential Applications

Inquiries received by the Bureau of Mines indicate that interest in high-damping Mn-Cu alloys has been aroused in a variety of applications such as: gears, machine frames, hearing aids, phonograph pick-ups, transducers, office machines, electronic components, high-fidelity audio microphones. Their unusual qualities are also under experimental study for aircraft and guided missiles in which sustained resonant vibrations have been known to cause self-destruction of vital members.

Phonograph pick-ups are usually marketed with a stipulation as to the range of audio frequencies over which they will respond with fidelity. Limits of the high-fidelity range are established by the unwanted resonance vibrations in the structure of the pick-up and playing arm, not by the response range of the stylus. Fig. 4 shows how Mn-Cu alloys prevent high amplitudes at resonant frequencies.

Another potential application is the construction of plates for tuning capacitors. Experimental work ("Use of Manganese Alloys for Electrical Condensor plates," by E. V. Potter and R. W. Huber, *U. S. Bureau of Mines Report of Investigations* 3689, February 1943) demonstrated that the vibration sensitivity of a capacitor constructed of conventional aluminum or brass plates was markedly reduced without loss of electrical properties when Mn-Cu plates were substituted.

Hardness and strength of the alloys make them quite suitable for gears which must be silent in operation. The alloys can be machined without serious difficulty and take an excellent finish which resists atmospheric corrosion. An experimental gear and pinion drive at the Bureau of Mine's laboratories showed good resistance to wear and corrosion and was quiet in operation after two and one-half years of service in a corrosive atmosphere.

EDITOR'S NOTE—Damping capacity of materials (steels, non-ferrous metals, plastics and wood—but not including the new manganese-copper alloys) was discussed in "damping capacity of materials," Alexander Yargiadis, *Product Engineering*, November 1954 page 164. The article develops method for evaluating the damping capacity and includes tables, charts and sample problems.

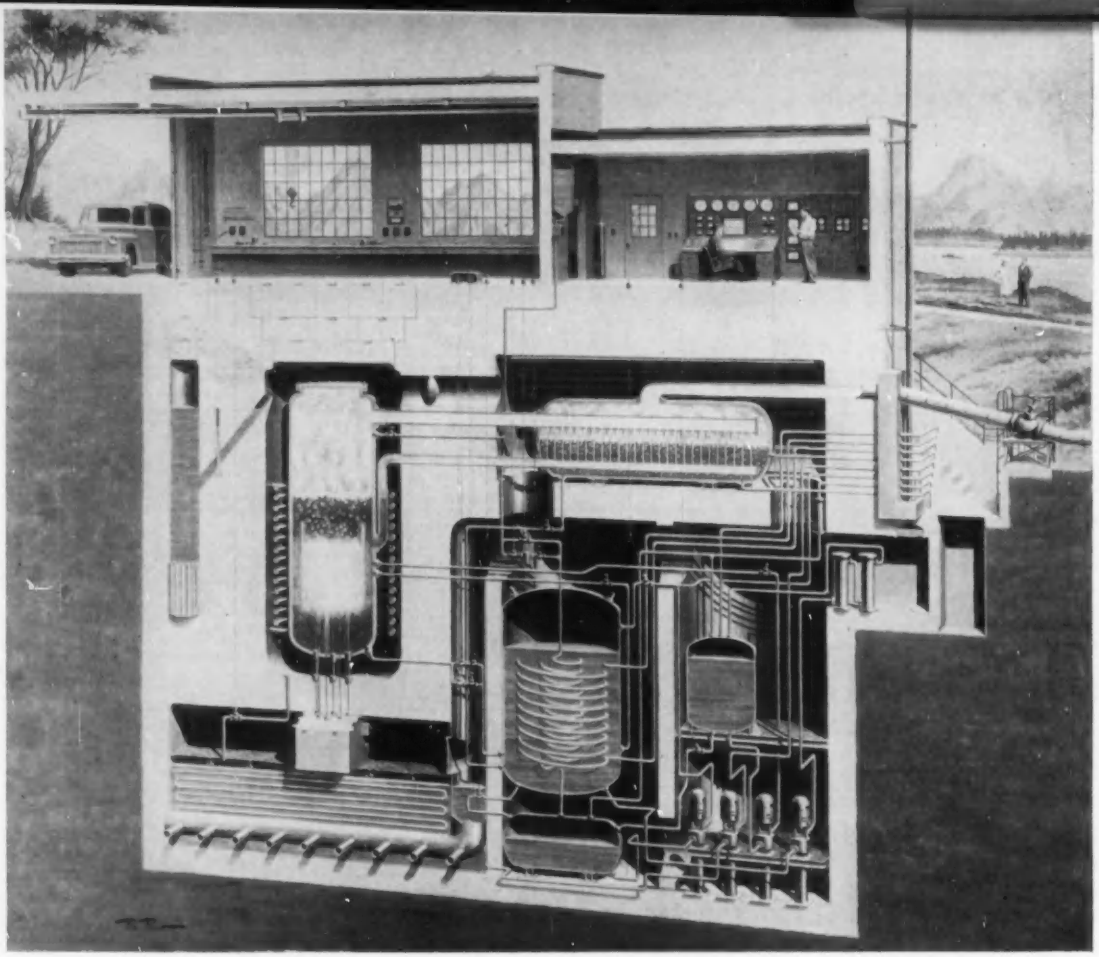


Fig. 1—This closed-cycle, Boiling Water Reactor was developed by the AMF Atomics, Inc., a subsidiary of American Machine & Foundry Co., for the Rural Cooperative Power Association, Minnesota. The reactor depends on natural convection to circulate the steam and water between the reactor vessel and boiler. The reactor was designed to serve small rural, central stations of about 10-20,000 kw capacity. The shielded primary loop operates at 1,200 psi, and the secondary loop has a 600 psi boiler supplying steam at 825F to a turbine.

Characteristics of Nuclear Reactors for power, production of nuclear fuel, and irradiation of materials

Types of devices for producing a controlled chain reaction; characteristics that define reactor performance, such as: type of fuel, energy range, coolant, moderator and shield, control system, and output; reactors now in use and under development.

Requirements of materials, mechanical components and controls are discussed in an article in the preceding issue "Nuclear Reactors Pose New Problems in Mechanical Design."

EACH NEW DESIGN in nuclear reactors, a device used to produce controlled nuclear power, Fig. 1, is being obsoleted before it gets to the building stage. This gives some idea as to the rapid advances in the field of nuclear power. The atomic age dates back to the early 1940's, but already more than 150 different designs have been offered for power reactors to be used for steam generation. It has been reported that there are as many different

A nuclear reactor has been described as being nothing more than a structure which allows a critical mass of a fissionable material, like uranium-235, to be assembled, and a means of controlling the chain reaction which results from the assembly of the critical mass. This chain reaction is initiated by adding a neutron to the core of the U-235 atom, unbalancing it enough to cause it to split into two parts. At the time of the fissioning, from one to three high-speed neutrons are liberated. If any of these neutrons hit another U-235 atom, the reaction is continued. With each fission increasing the number of neutrons by, say two, new fissions are increased in geometric proportion leading to a chain reaction.

The main requirement for the continuance of the reaction is the conservation of the neutrons liberated by the initial fission. This is a difficult problem, for the chance of a neutron hitting a U-235 atom is not great, whereas there are many chances for the neutron to escape across the boundaries of the system, or to be absorbed by an atom other than U-235. If this absorption is not prevented, the reaction stops; but if the rate can be controlled to permit a chain reaction, it will be possible to liberate heat energy at any desired rate. This heat is removed, in the form of a "coolant," and is put to work.

ideas for nuclear reactors as there are reactor engineers.

Equally complicating are the many ways by which a reactor may be classified. Five types have received extensive publicity: Pressurized Water; Boiling Water; Sodium Graphite; Fast Breeder; and Homogeneous. However, this list resulted from the Joint Congressional Committee on Atomic Energy requesting the Atomic Energy Commission (AEC) to set up a five-year program of reactor development. The AEC listed these five types which had been explored for several years, and had been picked as the most promising. A sixth, which can be added to the list, is the Liquid Metal Fuel Reactor. See Figs. 2-7.

Actually, a nuclear reactor can be classified in any of nine ways; and to accurately describe it, requires a check list of the following:

1. **Homogeneous or Heterogeneous.**
2. **Type of fuel**–Uranium 235; Plutonium; or U-233.
3. **Energy Range**–Fast; Thermal; or Intermediate reactor.
4. **Use**–Power producers; Production reactors; Research reactors.
5. **Type of Moderator**–Solid: graphite; beryllium oxide; beryllium carbide. Liquid: light water; heavy water. Reflector.
6. **Type of Shielding**–Water; Concrete; Steel; Lead.
7. **Type of Coolant**–Liquid metal; Light water; Heavy water; Gas.
8. **Type of Control**–Reactivity Control Rods: Boron; cadmium; hafnium.
9. **Heat and electrical output.**

1. Homogeneous or Heterogeneous

In a homogeneous reactor the fuel is in liquid form, being dissolved in water. The uranium used is in the form of a salt, such as enriched uranyl sulfate and uranyl nitrate. Also, the fuel may be a low melting liquid-metal system like the uranium-bismuth combination used in the Liquid Metal Fuel reactor. This solution is circulated through heat exchangers to give up the heat produced during the fission process.

This system is completely self-regulating and does not require the control rods used in the heterogeneous type. The reactivity control is regulated by the concentration of the fuel in the reactor core. This is an important advantage cost-wise, for fuel elements and control rods are an expensive fabrication item.

Another advantage to this system is the ability to remove the fission products continuously for processing while the reactor is in operation. Disadvantages are the handling of highly radioactive solutions under high pressure. Because the so[illegible]n is quite acid, there is a corrosion problem. The liquid metal fuel reactor will be operated at temperatures up to 1000 F, with a resultant high efficiency on the steam end. Another liquid fuel system has been mentioned as being adaptable to a high power output, however, the temperatures involved are so high that such a reactor has not been seriously considered. This system would use molten uranium as a fuel. Uranium has a melting point of 2070 F.

In the heterogeneous reactor, the fuel is of the solid type, in metallic form, and arranged in some regular pattern. It can be alloyed or mixed with an inert material to give better heat conductivity and mechanical strength, or to reduce radiation damage. The fuel elements, while built up into rod assemblies, assume a wide variety of shapes and configurations for better heat transfer. These elements may be rods, tubes, plates, wire, slugs, wafers, pellets, foil, and others. Uranium corrodes easily under high temperature, and must be clad with either aluminum, stainless steel, or zirconium. This cladding also protects the fission products in the form of radioactive gases from combining with the coolant. See Fig. 8.

Control of the fissioning process in a heterogeneous reactor is done with "control rods." These rods are made of a neutron absorbing material, like boron or cadmium, and are either inserted into or withdrawn from the core to adjust the neutron flux, or power level. This will be explained further in the section on type of control. Several examples of heterogeneous reactors are the Sodium-Graphite Reactor, the Pressurized Water Reactor, the Boiling Water Reactor, and the Experimental Breeder Reactor. These are shown in the illustrations.

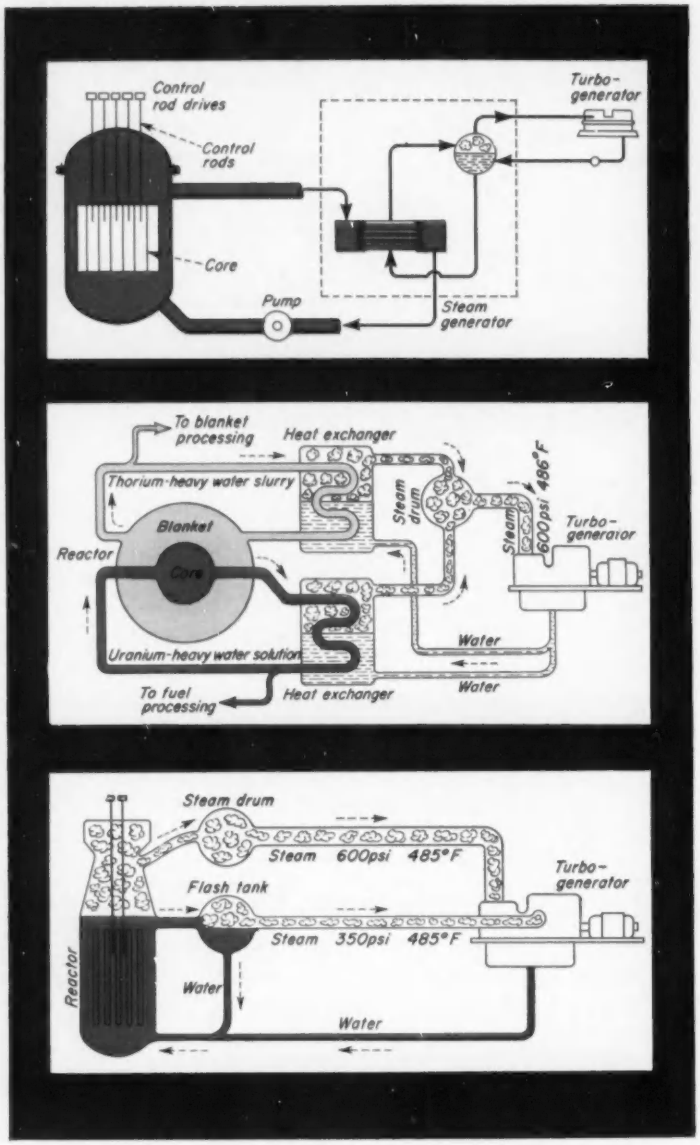
2. Type of Fuel

There are three fissionable materials which can be used as fuels: (1) Uranium 235; (2) Uranium 233; (3) Plutonium 239. Uranium 235 is obtained by separating nonfissioning natural

Fig. 2—This Pressurized Water Reactor, as designed by Westinghouse Electric Corp. for the Duquesne Light Co., will generate about 300,000 kw of heat in the core, and supply steam to turn a turbo generator which will have an electrical output of more than 60,000 kw. The heat will be transferred to a heat exchanger by circulating water at a pressure of 2000 psi, and 525 F. This is expected to produce 600 psi saturated steam for turbine use. The vessel will be made of stainless-clad carbon steel 8½ in thick, 9 ft in dia, and 32 ft high. The principle of this reactor is essentially the same as that used in the submarine Nautilus, but it will use as fuel slightly enriched uranium instead of the highly enriched U-235 used in the submarine version. The reactor used by Duquesne will be the first civilian nuclear powerplant but is not expected to produce economical power.

Fig. 3—The Homogeneous Reactor is different in appearance from other reactors in that it uses no mechanical control rods to regulate the fissioning process. Instead, the fuel is a dilute solution of uranyl sulfate in either light or heavy water. The solution serves as the fuel, the moderator, and the heat transfer medium. The solution is pumped through the reactor core where it is heated by fission, then to the external heat exchanger where a fairly high pressure, non-radioactive steam is generated. The core design is simple, and fuel stability is not a problem. The fission products formed can be chemically processed while the reactor is in operation, and additional fuel can be injected. A heavy water reflector surrounds the core. When the reactor also serves as a breeder, a blanket of non-fissionable thorium replaces the reflector, and U-233 is produced.

Fig. 4—A Boiling Water Reactor is another design concept testing the possibility of boiling water in the core of the reactor and sending the steam directly to the turbine. The advantage here is the elimination of any external heat exchangers. Also, the steam pressure and temperature can be as high as the conditions in the reactor vessel, thus increasing the over-all thermal efficiency of the plant. The difficulty with the boiling water reactor is that during a change in load, a demand for more power boosts the steam flow from the reactor, reducing the reactor pressure. The water flashing into steam in the reactor actually inhibits the chain reaction, reducing power when it is needed most. General Electric's new dual-cycle system (right), which replaces a single drum type prevents this.



uranium (U-238), which is made up of 99.3 per cent U-238, and 0.7 per cent U-235. The degree of "enrichment" of U-235, as the term is used, refers to the amount of U-238 left in U-235. For example, a 90 per cent enriched U-235 means that only 10 per cent U-238 remains in it. Thorium, three times more abundant than uranium, is not fissionable, but when bombarded with neutrons becomes uranium 233. Plutonium 239 is the result of bombarding U-238 with neutrons.

3. Fast-Thermal-Intermediate Reactor

One of these prefixes to a reactor designates its neutron energy range. A fast reactor has no moderator, that is, a material used to slow down the fission neutrons (see next section on Moderators). These reactors are difficult to control, and sensitive and quick operating control mechanisms must be used. The chain reaction is based on fission by the absorption of **fast** neutrons. The atomic bomb is of this type, since the multiplication and energy release must be rapid. Either plutonium or enriched uranium is necessary for this type of reactor.

Just the opposite of the fast reactor is the **thermal** or slow reactor, which is the most common type used today. This type uses low energy neutrons for fission, and uses natural or unenriched uranium as fuel. This low cost fuel, plus safety of operation are advantages of the thermal reactor.

Intermediate reactors use neutrons of energies between the fast and the thermal levels. This type is larger

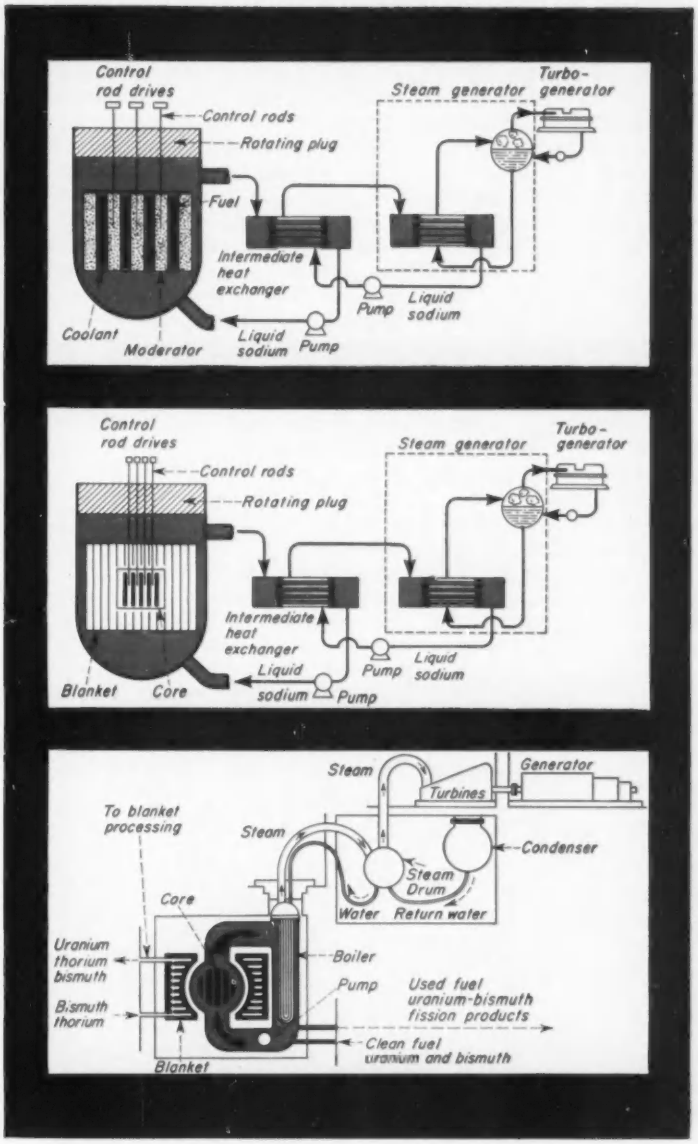


Fig. 5—A Sodium-Cooled, Graphite Moderated reactor which will be used in the Seawolf, the second nuclear powered submarine. It is called the SIR (Submarine Intermediate Reactor), and was built by General Electric. Features of this system are that it has no radioactive fluids under pressure, and produces steam of a high temperature and pressure. Thermal efficiencies are increased without a large increase in construction costs. To avoid the danger of placing the highly radioactive sodium near water, the coolant gives up its heat to a second sodium loop in the primary heat exchanger. The non-radioactive sodium then gives up its heat to the water in the secondary heat exchanger. In some installations, sodium-potassium is used as the coolant in the secondary loop. Sodium becomes highly radioactive when irradiated, making addition shielding necessary.

Fig. 6—The Fast Breeder Reactor, like the sodium-graphite reactor, uses liquid sodium as the coolant, but is completely different in principle. It uses highly enriched U-235 as a fuel, but does not have a graphite moderator for slowing down the neutrons. Instead, it is surrounded by a blanket of non-fissionable U-238 which is converted into plutonium by the bombardment of the neutrons in the fissioning U-235. With proper design it is possible to produce more new plutonium than the amount of fuel that is destroyed in the fission process. Because moderation of neutrons cannot be tolerated, the materials must be limited in volume. Note the small size of the core compared to that of the sodium-graphite reactor. The schematic diagram here is that proposed by the Detroit Edison Co. for the construction of a fast breeder reactor which will supply steam to a 100,000 kw power plant.

Fig. 7—The Liquid-Metal Fuel Reactor is of the homogeneous class in that the fuel is circulated as liquid slurry. However, instead of using water, as is done in the homogeneous reactor, the uranium fuel is dissovled in liquid bismuth. This solution can be pumped through the reactor and one or two heat exchangers. In one proposed unit using two cooling cycles, a liquid lead-bismuth is the secondary coolant. Very high steam pressures and temperatures (1400 F) are possible with this system. The liquid-metal fuel reactor using U-233 as a fuel may also be used as a breeder if the thorium blanket is used. Disadvantage of the system is the low solubility of uranium in bismuth. Also, the system requires an external heat source for starting up the reactor, as bismuth melts at 520 F.

than the compact fast reactor, but not as large as a thermal reactor. The fast reactor holds great promise for practical power systems, because it is small in comparison with other reactors, and most materials used for construction have a lower absorption for fast neutrons than for slow neutrons.

4. Power; Production; Research Reactors

The power-producing reactors will be used in power plants, where the heat produced in the reactor converts water to steam, which in turn drives a turbo-generator. The same type of installation is used aboard ship or in a submarine as the means of propulsion. A power reactor is now being tested for aircraft use; however, its design details have not been released.

A production reactor makes additional fuel by what is called a "breeding" process, Fig. 6. Some power reactors are designed to breed additional fuel, although its main function is for power. These are called dual-purpose reactors. Maximum power output is not possible if reactor is also used for breeding. The materials used in the breeding process are: uranium 238, which is converted into plutonium; and thorium, which is converted into uranium 233. Plutonium is used in the manufacture of atomic bombs.

A power reactor which also produces additional fuel, is called a "converter." If the reactor produces more fuel than it burns (it is possible to produce twice as much as that being consumed), it is called a "breeder" reactor. The material to be converted

into fuel is placed around or in the core of the reactor, where it is exposed to neutron bombardment. A power reactor for ship, submarine, or aircraft propulsion is designed to fit into the smallest possible space, and not breed new fuel. Highly enriched uranium 235 is used as fuel so that the maximum number of neutrons produced in the chain reaction will be available for producing additional fissions, and not directed to converting fertile to fissionable material.

Research reactors furnish neutrons for research on: physical or chemical processes; measuring the amount of neutron shielding provided by the different materials used in large scale design models; the effect of radiation on materials, Fig. 9; the generation of radioactive isotopes; and others. The medical reactor is a type of research reactor used for medical research and therapy.

5. Moderators

The function of a moderator is to reduce the neutrons of fission energy to thermal energy within the smallest space and with the least loss of neutrons. A term applied to a moderator is its "slowing-down power." The main requirement of a moderator is that it be made from one of the lightweight elements. All of the elements from hydrogen through carbon (atomic weights 1 through 12) are eligible, but because of the high neutron cross section, or low atom density of some, only hydrogen, deuterium, beryllium and graphite can be considered. The moderator also must be made in a form which permits the mechanical load of the reactor to be transmitted through these materials. With water and heavy water, the load is transmitted to the vessel holding the water.

Graphite is a good moderating material because it has a low thermal neutron absorption cross section, a high moderating ratio, good thermal conductivity, strength and creep resistance at elevated temperatures, and high thermal shock resistance. Beryllium differs from most metals in that it is the only light metal (density 1.82 g/cc) with a high melting temperature of 2340 F. For reactor use, the oxide, with a melting point of 4585 F, is preferable. Availability and cost are the prime factors affecting the consideration of beryllium for neuclear use.

Water, sometimes called "light" water as opposed to "heavy" water, or deuterium oxide (D_2O), is a good moderator because of its good slowing-down power. Many reactors now in use have water as a mederator because of its low cost and availability. Water has another advantage in that it can be used as a combined moderator, shielding material, and coolant. The "swimming pool" type reactor is an example of this use. However, water may decompose under irradiation and produce hydrogen and oxygen gases and some hydroperoxide. The reactions involved in this decomposition are still not understood.

Heavy water is considered a good moderator for slowing down fast neutrons, and is about four times as efficient as graphite. With some limitations, heavy water can be used as a combined moderator-coolant with natural uranium in either heterogeneous or homogeneous power reactors. The cost of this fluid is about $80 per pound.

When a nuclear chain reaction is going on in a reactor, the neutrons liberated in the fission process are used to sustain the chain reaction for control purposes or for breeding. However, some neutrons escape from the chain reaction and actually perform no useful purpose. This is an expensive leakage, because these neutrons are not available to help in maintaining the chain reaction and more fissionable material must be added as fuel. To prevent this leakage and thus increase the reactor's efficiency, these neutrons are "reflected" back into the reaction by a material known as a reflector. This reflector is nothing more than a low cross-section material which allows the neutrons to collide with its own nuclei without absorbing any neutrons.

If the reactor is a thermal reactor (requiring low energy neutrons for fission), the reflector can be made of a moderating material. Conse-

Fig. 8—Reactor fuel element shapes made by Sylvania Electric Products, Inc. Besides containing uranium or thorium in metallic or compound form, fuel elements can consist of a wide range of materials. These materials are used either in conjunction with the uranium or thorium as an alloy, cermet, or mixture in the fuel core, or as a cladding to protect the fuel from corrosive attack. Some of these materials are stainless steel, nichrome, aluminum, magnesium, zirconium, beryllium, titanium, nickel, chromium, copper, silicon, niobium, and molybdenum.

quently, when a neutron is reflected back into the reactor core, it has lost most of its kinetic energy and is of more use to the chain reaction than if it had been reflected back with its original kinetic energy. If the reactor is a fast type (relying on the use of high speed neutrons and having no moderator), the reflector should be an element of high mass such as iron, so the neutrons will be reflected back into the core with most of their original kinetic energy. Or, the reflector element should be one of those in the upper end of the periodic table where atomic-scattering cross sections are high, such as bismuth and lead.

6. Reactor Shielding

Without some sort of shielding around the nuclear reactor, its operation by man would be impossible from a safety standpoint. And because of shielding, and its necessary bulk, its application to automobiles and trains must be relegated to the very distant future. Reactor radiation consists of fast and slow neutrons, gamma rays, and alpha and beta particles. Only the gamma rays and neutrons require material of appreciable thickness to provide protection against radiation, for the alpha and beta particles can be stopped effectively by relatively thin pieces of metal.

Gamma rays interact mainly with electrons; therefore, this type of radiation can be best absorbed in materials of high density containing a large number of electrons per atom. Lead, tungsten, and iron are good materials for shielding against gamma radiation.

Fast and intermediate energy neutrons can be absorbed only in a limited way by most materials, but can be slowed down by certain materials. For this latter purpose, materials with a large hydrogen content, particularly water, are best. The neutron loses a large part of its energy in one collision with a hydrogen atom. These low-energy neutrons can then be absorbed in materials of very high neutron cross section (those having a high affinity or capturing ability for thermal neutrons). Boron is the best choice of material for this job. Concrete contains a large amount of hydrogen as either free or combined water, and is used quite frequently as a shielding material.

While water is the ideal substance for neutron shielding, it is not a good gamma shield, because of its composition of elements of low atomic number. However, heavy elements that stop gamma rays are poor for the reduction of neutron energy. The best combination, then, is a water shield plus a layer of cement, providing the cement has iron or borium ore as part of the aggregate for neutron absorption.

Besides radiation shielding, there is the problem of "thermal" shielding. This shield is between the reactor and the bulk of the radiation shield. The thermal shield is exposed to the high temperature of the core, and is heated by gamma radiation. The thermal shield must be capable of withstanding thermal stress and possible corrosion if a thermal-shield coolant is necessary. This would indicate iron or steel. Oak Ridge National Laboratory has developed thermal shielding materials consisting of boron carbides and aluminum; also, boron oxide and aluminum.

7. Coolants

During the fissioning process the reactor is a constant source of heat, and a coolant must be provided to: (1) take advantage of this heat and have it produce some useful power, and (2) prevent the reactor core and fuel elements from overheating and melting. Coolants are usually fluids (light water, heavy water, liquid metals), but gases also are used.

For a fluid to be a good coolant, it must have the following qualities: (1) a fairly high heat capacity; (2) be relatively non-corrosive to the fuel element and other parts of the reactor; (3) be stable under irradiation; (4) have a material of low neutron capture cross section. Water is the most common coolant because its heat transfer coefficient is good, and it has good moderating as well as shielding properties. Furthermore, it is available in large quantities at low cost.

Water's disadvantages are that at high temperatures it builds up high pressures which necessitate special piping systems and heat exchanger design. Also, because of its impurities, some of which have high neutron capture cross sections, water presents corrosion problems with materials at high temperatures. This coolant, called the primary coolant, is pumped through a heat exchanger containing the secondary coolant. This secondary coolant, usually water, is converted to steam and sent to the turbo-generator.

One of water-cooled reactors is the swimming-pool type. Of the heterogeneous (solid fuel) type, it also is

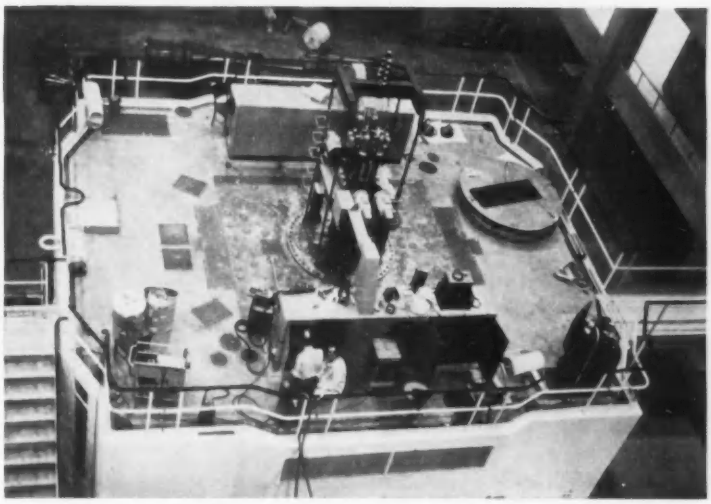


Fig. 9—Top view of the Materials Testing Reactor at the National Reactor Testing Station, Idaho Falls, Idaho. This reactor is being made available to industry to provide information on the effects of irradiation. The plug in the center is removed to insert new fuel elements. The driving mechanism for regulating the cadmium control rods is mounted on top of the plug. Small circular areas on floor are covers to experimental holes extending into the graphite zone of the reactor.

water moderated, and is designed to produce large quantities of neutrons. The core is placed in about 20 ft of water which cools the reactor, absorbs the radiations and slows down the fast neutrons to a usable range.

Another water-cooled type is the Boiling Water Reactor, Fig. 10, a relatively simple and safe unit. Steam at about 600 psi is generated within the reactor itself and sent directly to the turbine. A test of this reactor showed that it is inherently safe. All of the control rods were suddenly withdrawn, but instead of running away, it shut itself down. The sudden increase in steam choked off the chain reaction.

The Pressurized Water Reactor also is water cooled, but because of the high pressures developed, special construction is necessary. Its design is to prevent boiling of the coolant. It has a primary coolant under a pressure of from 1500 to 2000 psi, which gives up its heat to the secondary coolant in the heat exchanger. The submarine Nautilus uses a pressurized water reactor.

A coolant using heavy water will be an expensive but efficient system. Heavy water also is the best moderator, because it absorbs practically no neutrons. It is possible to have a reactor with a heavy water coolant moderator.

The primary advantages of liquid metal coolants are the high temperatures at which they can operate, and the high heat transfer coefficients possible. Low pressure is another significant advantage. While several metals have been tried, only two have been used extensively—sodium, and an alloy of 56 per cent sodium and 44 per cent potassium. Liquid sodium has a melting point of 208 F and a heat conductivity of about 140 times that of water. Sodium-potassium melts at practically room temperature (66 F). The system must be particularly leakproof, inasmuch as the metals react violently in water.

Another requirement is that it must be possible to heat all parts of the system to re-melt the metal, in case it solidifies. Operating temperature of the liquid metal system can be as high as 1000 F. Pumping of the liquid metal usually is done with induction type electromagnetic pumps. While this type of pump needs no bearings or seals, resulting in leaktight operation, it is not as efficient as a mechanical pump of an equal rating. In most cases, the primary sodium coolant, Fig. 5, 11, in the primary heat exchanger, gives up its heat to a second sodium-potassium coolant, which in turn gives up its heat to the water in the secondary heat exchanger. This is done to keep the highly radioactive sodium away from the water.

Most of the gas-cooled reactors make use of air as the coolant. The cooling air temperatures are low and are not intended to produce useful power, where the reactor is used strictly for research purposes. However, a high temperature model of such an air cooled reactor has undoubtedly been considered for aircraft use, Fig. 12. The construction of the present gas turbine would be the same, except that a reactor would be used in place of the present gasoline or kerosene combustion chamber to heat the compressed air.

Another high temperature application for a gas-cooled reactor is for the generation of electric power. A simple design of relatively low weight and space requirements is possible. Helium, while very expensive, has a high heat conductivity and serves as a good coolant. In France a heterogeneous, heavy water research reactor is using nitrogen at 10 atmospheres pressure as a coolant. Hydrogen is another possibility.

The advantages of an open system, air-cooled reactor are: simplification of the cooling system; use of conventional equipment, and minimized corrosion problems. However, with

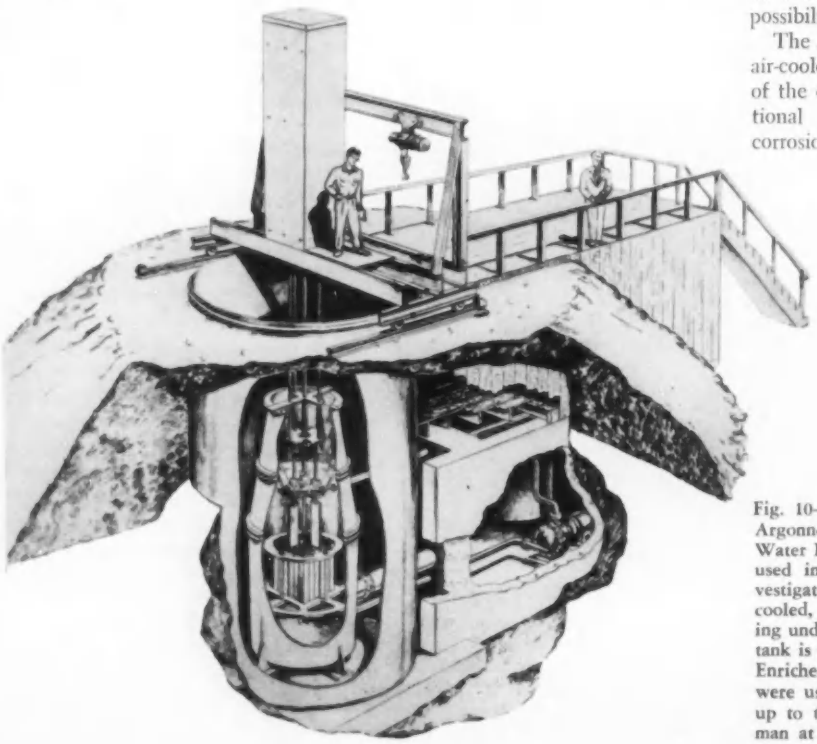


Fig. 10—A cutaway view of a model of Argonne National Laboratory's Boiling Water Reactor known as Borax I. It was used in a series of experiments to investigate the characteristics of a water-cooled, water-moderated reactor operating under boiling conditions. The reactor tank is about 4 ft. in dia. and 13 ft. high. Enriched uranium-aluminum fuel elements were used. The five control rods extend up to the operating housing behind the man at left.

air cooling, the size of the blowers and ducting is of necessity large, because of the low density air at atmospheric pressures. High power requirements are necessary for circulating the air, and a special filtering system is required before the radioactive air can be discharged to the atmosphere. This radioactive hazard is not caused by oxygen, but rather the argon present in the air which has a half-life of almost two hours.

The closed-cycle gas-cooled system has the same advantages of the open, plus elimination of fouling of the compressor or turbine blades. The disadvantages are supply problems, where helium is used, and particularly tight sealing to keep leakage to a minimum.

8. Types of Control

The power level of a heterogeneous reactor (solid fuel) is controlled by the insertion or removal of "control rods." These rods must be made of a strongly neutron absorbing material which increase or reduce the neutron flux, depending on the degree of their insertion into the reactor core. Actually, the term control rod is often applied in a general way to any device which changes the reactor activity. For example, some of the rods may consist of neutron absorbing metal shot spilled into metal tubes placed in the reactor core. For neutron flux control in large reactors, it is necessary to place several control rods in various places in the reactor.

The control of a nuclear reactor is measured by the multiplication factor, K, which is the ratio of the number of neutrons in one fissioning process to the number of neutrons in the fissioning process which just preceded it. This number must be at least 1 for a self-sustaining reaction, but in acutal operation the value of K varies slightly above or below unity in order to allow the level of fission rate (also power) to increase or decrease. This change is made by moving one or more of the control rods in the core of the reactor. These rods are so arranged that when they are in a reactor, K is less than 1, and any neutron causing a fission in the reactor will not start a continuing chain reaction. When the rods are removed, K is slightly greater than 1, and a neutron can start a continuing chain reaction which will increase in intensity with time. When the power level has been increased to the desired value, the control rods are moved to decrease the reactivity until K is 1, at which time the power level remains constant.

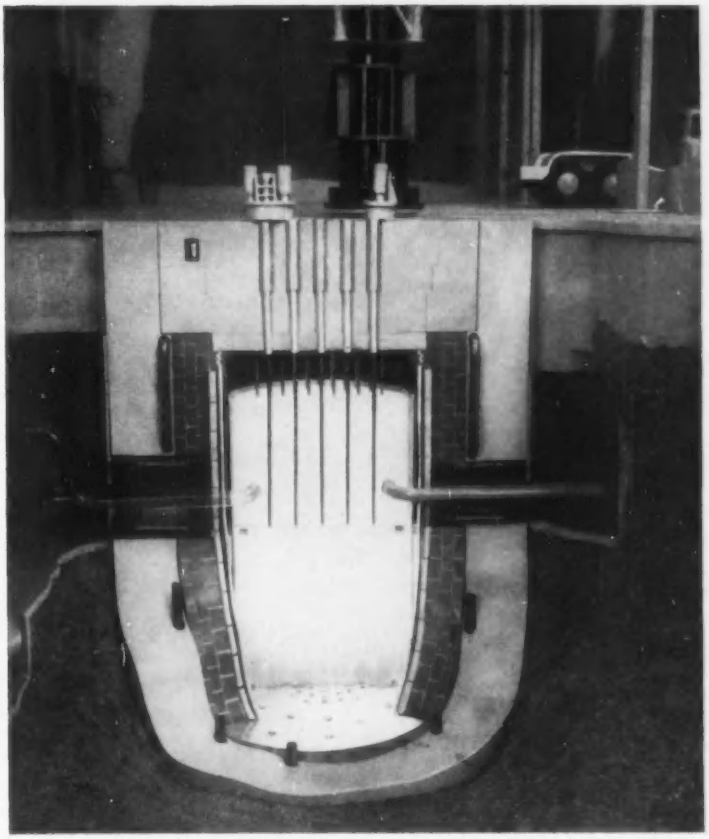


Fig. 11—Close-up view of a model of a sodium graphite reactor core, showing control rods, fluid, and shielding. Piping system to right and left of core circulates liquid sodium through reactor to absorb heat. This heat is transferred to a secondary system of sodium or sodium-potassium. In a heat exchanger water is converted into steam.

Materials which can be used for reactivity control are of the high cross section type. **Boron** is one of the most widely used materials, with a cross section of 750 barns. (A "barn" is a unit area equal to 10^{-24} cm ^{2}, and is a number applied to a nucleus to describe its relative affinity for absorbing neutrons without fissioning; the higher the cross section the greater the affinity for neutrons.) Boron's high melting point of 4170 F is another point in its favor. Boron can be used as metal, compound, or in the form of boron-steel shot.

Cadmium is another good reactivity control material from a cross-sectional standpoint, but it has limitations because of a low melting point of just over 600 F. *Hafnium* also may be used. It is a by-product of zirconium processing, and is so similar to zirconium that it is difficult to separate the two. It is expensive, has good corrosion resistance and physical properties, melts at about 3100 F, and welds easily. One of the rare earths, *Gadolinium*, with a cross section of 36,000 barns, would be good for fast acting control rods. However, this metal is found in only small amounts in its pure form.

Absorbers such as cadmium and boron are often clad in steel or aluminum for rigidity and protection.

Besides the control rods, there are safety rods, which provide several per cent of negative reactivity under all possible loading conditions expected for the reactor, with all other rods in their maximum positive re-

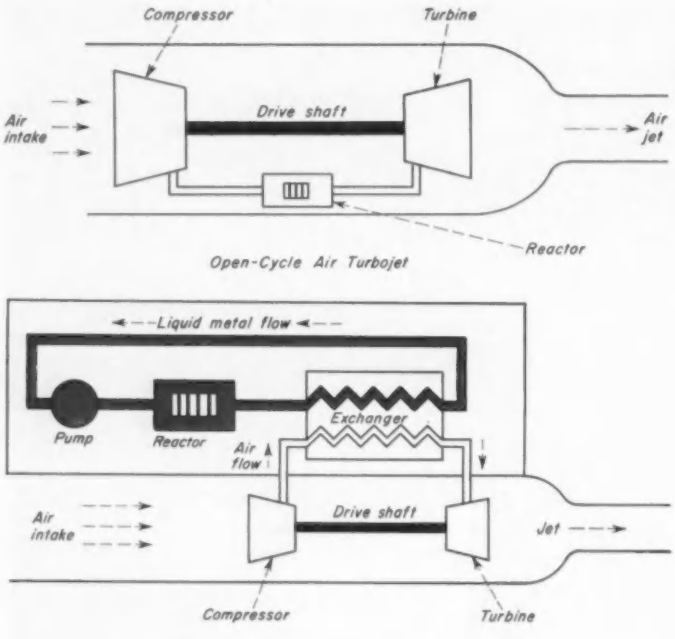


Fig. 12—Two suggested nuclear propulsion systems for aircraft use. In one (top), the cooling fluid, air, is used once and is expendable. In the closed-cycle (bottom), helium, mercury, or other metal coolants may be used. Advantages of the open-cycle with air is its simplicity. But its disadvantages are the danger of the oxidation of hot metal surfaces in the reactor, and the large volume of air needed to remove the reactor heat. Advantage of closed cycle is that the coolant may be selected specifically for that component, while the second coolant (air) can be used to drive the turbine and as a jet propellant.

activity position. Safety rods are usually magnetically latched in ready position for "scram" action (fast reactivity reduction), and are released under forces of gravity, springs, flywheels, or hydraulic pressure accumulators.

As was mentioned at the beginning of this section on reactivity control, only heterogeneous reactors are using control rods for this purpose. Homogeneous reactors, Fig. 13, use a fuel in solution with water or some other fluid, and the reactivity of such a reactor is controlled by the amount of fuel in solution in the core at one time.

9. Power Output

A reactor's level of operation is described by the kilowatt or megawatt whether or not it is used for practical power generation. A close relationship exists between the total power and average neutron flux. Both power and flux should be quoted in describing a particular reactor.

An important point in the comparison of reactors to be used for power is the efficiency of the conversion of heat into electricity. This problem is related directly to the type of coolant used. It has been estimated that the most economical temperature for a nuclear fuel steam plant will be between 600 and 800 F, which is lower than the average steam plant.

The output of several plants being built under the AEC Five-Year Plan are as follows: (1) Pressurized Water Reactor has a heat output of 264,000 kw and an electricity output of 60,000 kw; (2) Experimental Boiling Water Reactor has a heat output of 20,000 kw and an electricity output of 5,000 kw; (3) Experimental Breeder Reactor has a heat output of 62,000 kw and an electricity output of 15,000 kw; (4) Homogeneous Thorium Reactor has a heat output of 62,500 kw and an electricity output of 16,000 kw; and (5) the Sodium Reactor experiment has a heat output of 20,000 kw but no electrical output is given. (6) The Army's Package unit, being built at Fort Belvoir, Virginia is shown in Fig. 14.

Going over these nine basic points, the Pressurized Water Reactor, designed by Westinghouse Electric Corp. for the Duquesne Light Co., can be described as: (1) Heterogeneous; (2) Fuel is part Natural Uranium (U-238) and 52 kilograms of Highly Enriched Uranium (U-235); (3) Its neutron energy level is Thermal; (4) Main use is for power, but acts as a breeder with a 0.8 breeding factor; (5) Moderator is water; the reflector is also water; (6) Steel is used as a shield; (7) The coolant is water; (8) Control Rods are 24 X-shaped and made of Hafnium; (9) Heat output is 260,000 kw, and electrical output is 60,000 kw.

Other Reactor Concepts

Organic Moderated—This type uses an organic material which acts as a moderator and a coolant. The organic compounds being used are hydrocarbons known as di-phenyl and ter-phenyl. Their boiling points are high enough so that high temperatures are possible without high pressure. Temperatures of from 600 to 700 F are possible at close to atmospheric pressure without boiling. In addition, the organics are very good moderators, so that the core can be as compact as a water moderated reactor. There is the added advantage that the equipment for handling these organic materials is available, as they are similar to the commercially used Dowtherm fluids. Another advantage of the organics is that they will not present any corrosion problems.

New Type Homogeneous—Known as the Los Alamos Power Experiment Reactors, or the Test Tube Reactor Experiment, two new reactors are of the aqueous homogeneous type, but use a phosphate solution rather than a sulfate in the fuel system. The main advantage is that phosphate solutions may be more stable under irradiation. High concentration of uranium is possible, as there is no phase separation at high temperatures, which is true with the sulfate system. However, the phosphate solutions are more corrosive.

Fig. 13—Homogeneous Reactor Experiment No. 2 being loaded for shipment to Oak Ridge National Laboratory. The outside shell is called the blast shield. Inside that is a similarly shaped, thicker shell called the pressure vessel. Inside that is the core vessel of the reactor. Around the core circulates the thorium "blanket" material in which U-233 breeds. Inlets for this material are the two short pipes protruding at about 45 deg. angle near the bottom of the shell. Large flange with white cloth at bottom is the liquid fuel inlet. Outlet is at top. Large flange in foreground at top is blanket outlet. Small cooling coils cover exterior of blast shield.

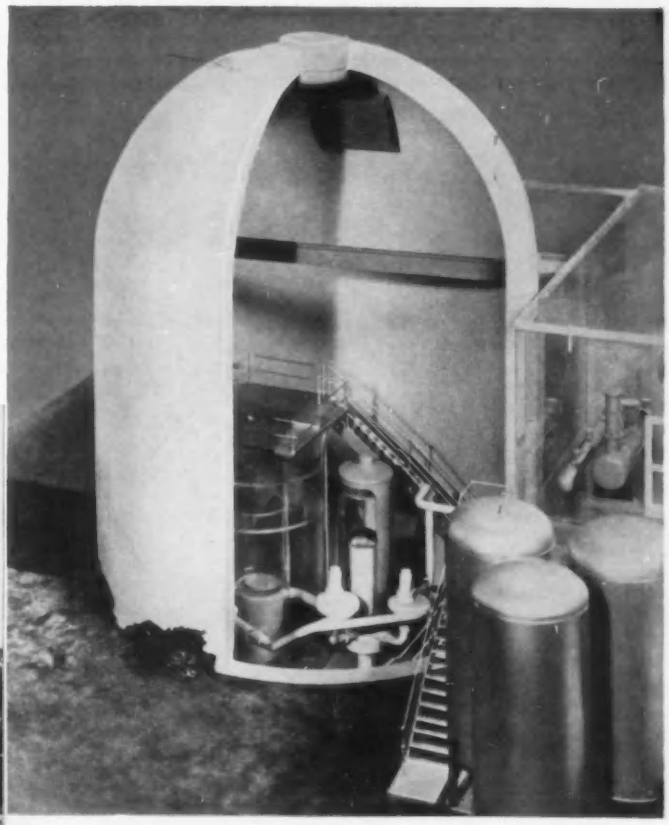


Fig. 14—Cutaway of the heart of Alco Products' Army Package Power Reactor (APPR). The reactor is shown at left at the edge of the container shell. Next to that are the primary pumps and the steam generator. Three water tanks are in the right foreground, and the feedwater and evaporator tanks in the background. Steam is generated at 200 psi absolute at 407F, which drives a generator developing 2105 kw. The large dome-shaped structure is the vapor container 36 ft. in dia., 64 ft. high, and lined with 2 ft. of concrete. The cylinder prevents any radioactive particles from being released to the atmosphere in case of failure of the lines or the reactor container.

EDITOR'S NOTE

For further data on types of reactors, performance and construction, the following references offer a good starting point:

Materials for Nuclear Reactors—H. H. Hausner, S. R. Roboff, Atomic Energy Div., Sylvania Electric Products, Inc., Bayside, N. Y.

Introduction to Nuclear Engineering—Raymond L. Murray, North Carolina State College of Agriculture and Engineering, Raleigh, N. C.

Proceedings of the International Conference on the Peaceful Uses of Atomic Energy, held in Geneva, Switzerland—Volumes 2, 3, 4, and 5, Columbia University Press, 2960 Broadway, New York 27, N. Y.

Nuclear Reactor Development—Atomic Industrial Forum, Inc., 260 Madison Ave., New York 16, N. Y.

Nuclear Metallurgy—A symposium conducted by the Institute of Metals Division of the American Institute of Mining and Metallurgical Engineers, 29 West 39th St., New York 18, N. Y.

The Pressurized Water Reactor Forum—Held December 2nd, 1955 at the Mellon Institute, 4400 Fifth Ave., Pittsburgh, Pa.

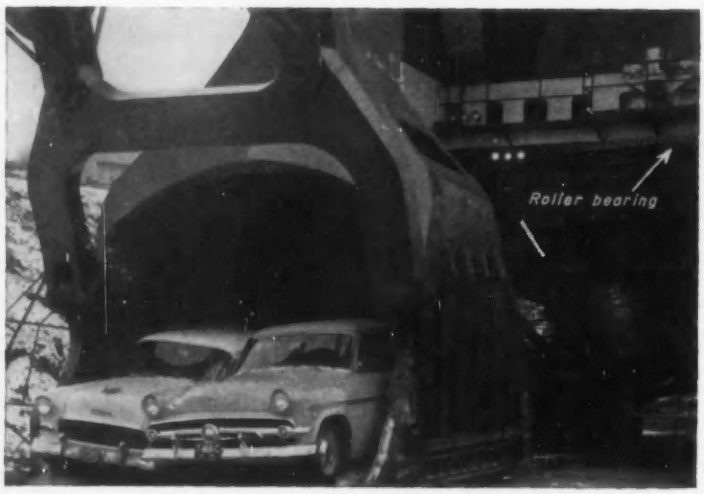
Industrial Applications of Atomic Power—Dr. W. Kenneth Davis, Director, Division of Reactor Development, Atomic Energy Commission, Washington 25, D. C.

Nuclear Reactor Data—Raytheon Mfg. Co., Waltham 54, Mass.

For additional information consult the list of references in the article "Nuclear Reactors Pose New Problems in Mechanical Design," wich appeared in the April 1956 issue of *Product Engineering*, page 187.

DESIGN FEATURES

THESE TWO PASSENGER CARS side by side in the dipper give some idea of the size of this shovel. The dipper handle is 90 ft long. Roller bearing under rotating platform is about 25 ft above ground level.



World's Largest Shovel

Height	155 ft
Dipper capacity	60 cu yd
Cycle time	45 sec
Handling capacity, per hr	7000 tons
Stacking height	100 ft
Hoist capacity	250 tons
Working weight	5,500,000 lb
Cost	$2,600,000

Electrical Drives in rated hp

Hoisting, 4 motors	1800
Swing, 4 motors	750
Crowd, 2 motors	375
Traction, 4 motors	1000
Main motor generator set	3500
Second motor generator set	1000
Total rating, all equipment	12,000

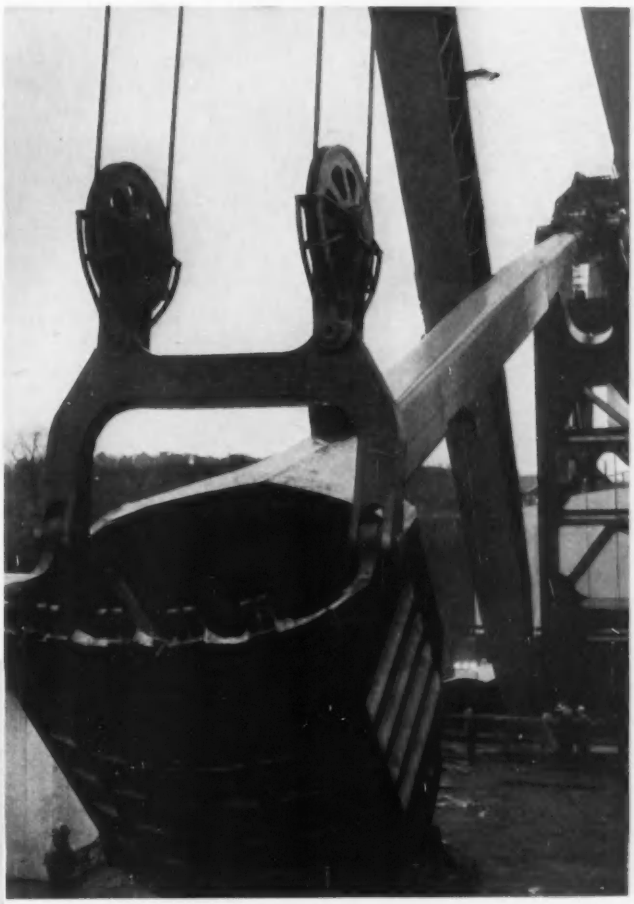
High Strength Steels Key Factor in Design of World's Largest Shovel

With a dipper capacity of 90 tons (60 cu yd) and a cycle time of 45 sec (fill dipper, rotate 90 deg and dump, and return), this "world's largest" self-propelled power shovel can move strip mine overburden at the rate of 7000 tons per hr, stacking at a height of 100 ft.

Shovel was built by Marion Power Shovel Company for Hanna Coal Company, with electrical equipment designed by General Electric Company.

Largest shovel built prior to this one had a 45 cu yd dipper with a 60 ft handle. Principal factors contributing to increasing the dipper to 60 cu yd with a 90 ft handle were:

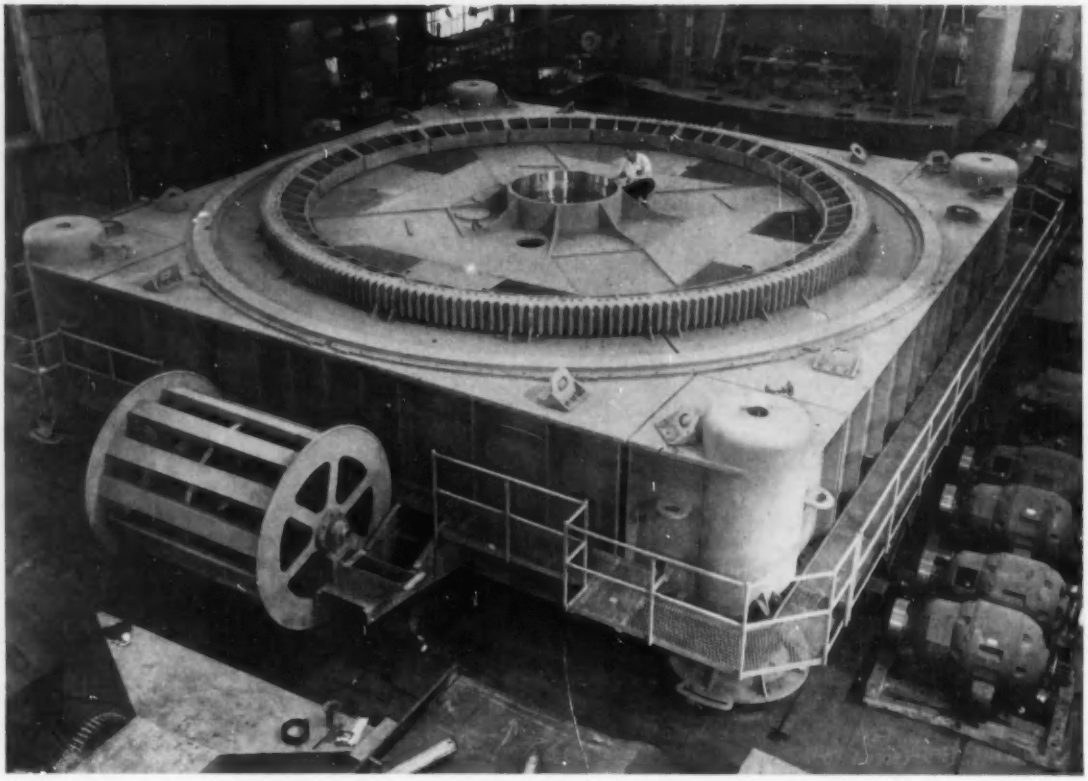
1. All-welded design using high strength steels where reduced weight of parts resulted in increased load capacity.
2. Variable-speed electrical drives for hoist, swing and crowd functions with power rating and speed of response exceeding any previous drive.

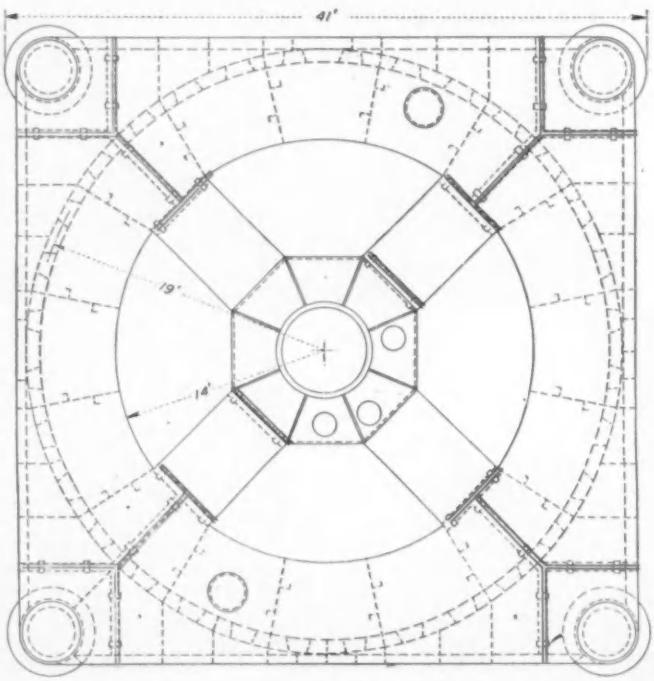


WEIGHT OF DIPPER, bail and handle was reduced enough through use of T-1 high strength weldable steel to nearly double the dipper capacity over an equivalent design using low-carbon structural steel. Alloy steel plates were purchased in the heat treated condition with a yield strength exceeding 100,000 psi. Welded construction was used throughout with parts stress relieved after shop welding. Plate forming lip of shovel is 6 in. thick. Handle consists of two U-shaped plates welded together, with joint located on neutral axis.

Boom weight was kept to a minimum through the use of a built-up lattice construction developed for earlier models but stepped up in size. Top and bottom chords are designed for minimum possible thickness; webb used in conventional truss design is replaced by tubular members welded in place.

(continued on next page)



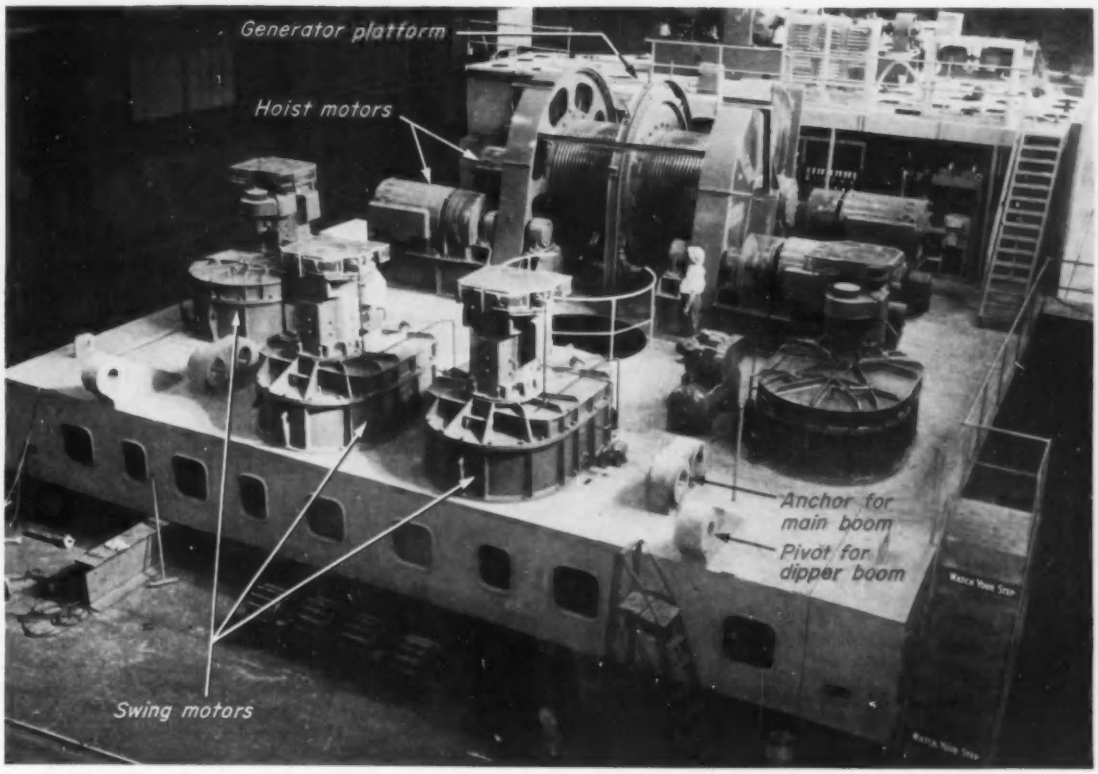


LOWER FRAME (shown here during erection in the shop) is a square unit carrying a circular beam 40 ft dia and 8 ft deep. Top deck is 2½ in. thick to provide stiff support for the lower race of the roller bearing. Cylinders at each corner are one-piece forgings. Structure was welded in seven sections, bolted together for machining top surface and for roller race and ring gear. Frame was then broken down for shipment and welded solid in the field.

Cylinders at each corner take pistons supported by the four pairs of crawler treads. Hydraulic system automatically keeps frame level as shovel moves over uneven ground (more details in a later issue).

Center bushing is cast iron with a bore of 6 ft. Center pin is hollow and encloses an elevator shaft for reaching operating deck and gantry while machine is in motion.

Ring gear is assembled from 16 built-up segments. Gear teeth are flame cut to finished dimensions. Swing drive is through four separate motors each with its own pinion engaging the ring gear. Quadruple drive reduced tooth loads, kept the gear face width to 13 in. and shortened the overhung length of the pinion. The electrical system automatically equalizes the load on each pinion.

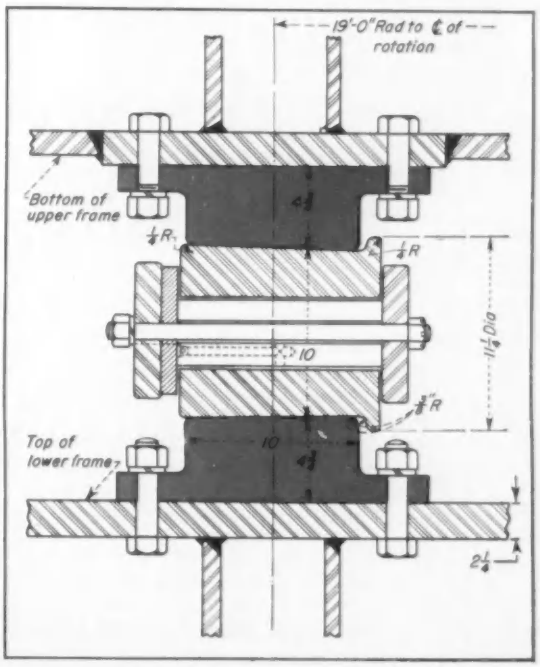


UPPER FRAME (during shop erection). Sectional construction was used here also to break down the assembly for shipment to the site. The four vertical swing motors are shown. Hoist drive also uses four direct-geared motors, and load equalizing is accomplished electrically. Note each motor is separately cooled by own motor-driven centrifugal fan.

Methods used to obtain load equalization, as well as full range of variable speed control, load limiting functions and desired range of torque performance will be the subject of a feature article in a coming issue.

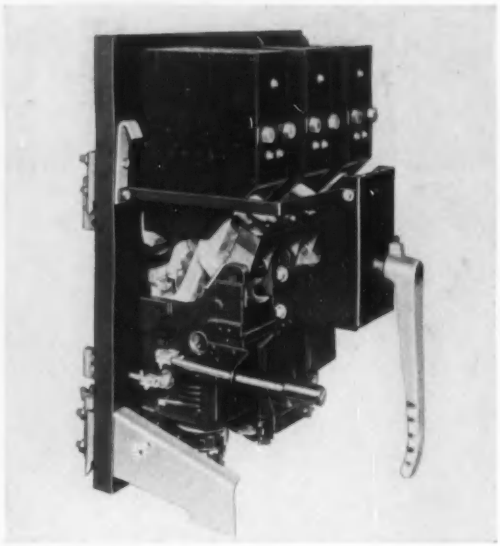
FRAME SWINGS on a 38 ft dia tapered roller bearing having 10 in. dia rollers of high-carbon steel, quenched and tempered. Loosely fitting retainers are drilled for automatic lubrication.

Races were formerly rolled to circular segment shape from bars faced at proper angle to keystone to taper matching the rollers. For more equal distribution of load between rollers, the new rail design employs segments cast of cr-ni-mo steel and heat treated. Segments are assembled together and milled accurately to taper on a 40 ft mill. To further assure even load distribution the lower frame itself is milled flat before the rails are assembled.

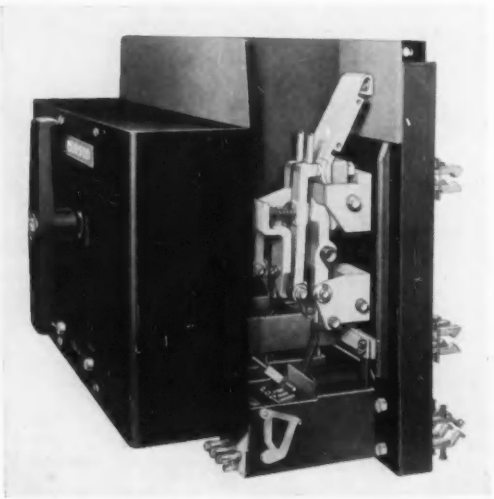


Circuit Breaker Redesigned for Less Space

A compact operating mechanism enabled engineers at the Boston Works, of Allis-Chalmers Mfg. Co., to redesign a line of air circuit breakers to occupy less volume but have improved operating features. Improvements include "dead-front" construction for greater safety, hydraulic closing for less jarring, wiping contacts for dependable performance and fewer parts with more interchangeability.



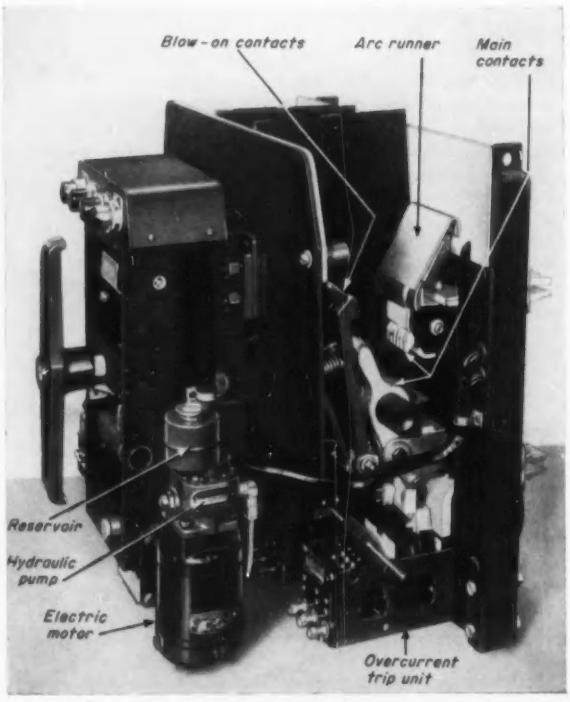
Old Design . . .

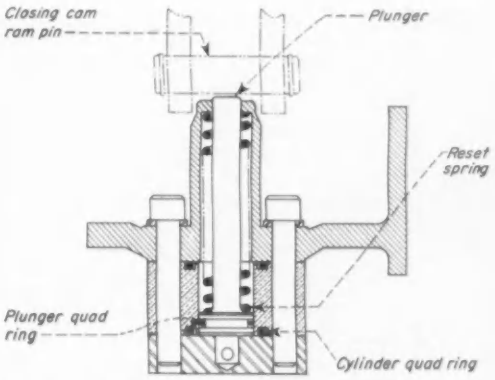


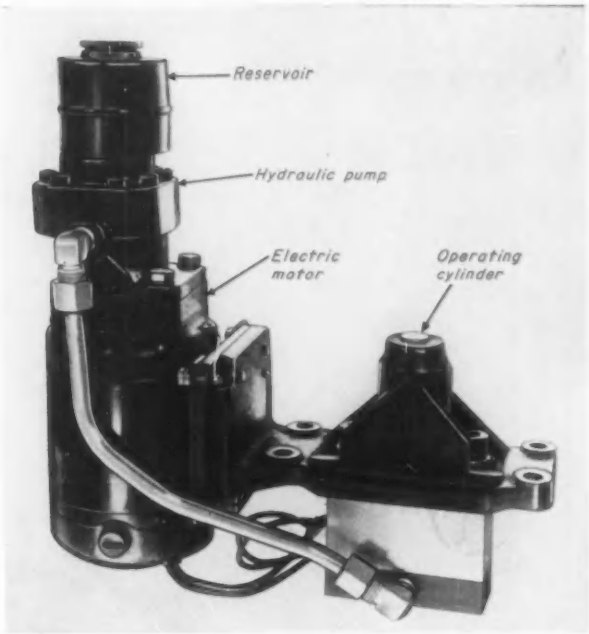
New Design . . .

SPACE LIMITATIONS were a severe design objective; necessary clearances, space for buswork, etc., reduce the volume for each breaker to a space 13 in. wide by 18 in. deep and 19 in. high, with projecting operating handle and rear disconnect devices. Old design was 24½ in. high compared to 19 in. for new unit which has superior electrical and mechanical performance. Many components are now interchangeable over a wide range of ratings. Other objectives included blow-on contact structure, "dead front" construction to prevent injury to personnel, interchangeability of parts, improved time delay and trip mechanisms and ability to operate in severe environments with little maintenance.

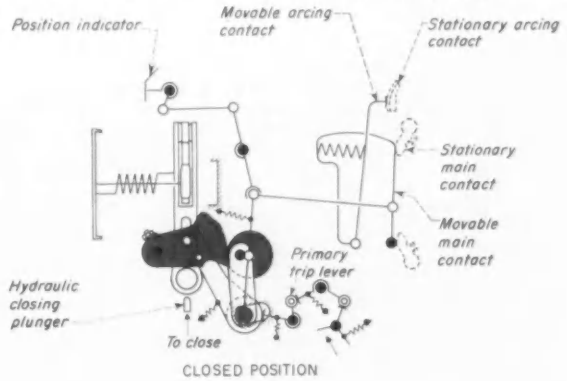
A SIMPLE AND RELIABLE hydraulic mechanism closes the breaker directly from an a-c power source. A closing time of 8 cycles is obtained with almost no jarring characteristics; this allows correct adjustment to be maintained indefinitely. Four components form the hydraulic system: a 1 hp electric motor, a direct-connected reversible pump, a 3 cu in. reservoir, and an operating cylinder. A single length of tubing and two fittings connect the pump and the operating cylinder. The motor is a compact universal sealed bearing type which reaches rated speed within 5 cycles. The gear-type pump has a built-in pressure relief valve normally set at 2500 psi.



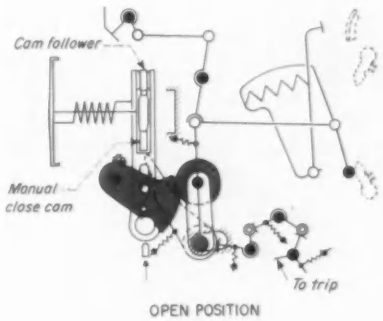




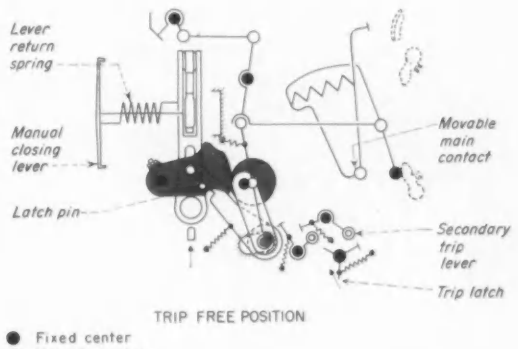
PUMP FORCES OIL from reservoir to cylinder and drives piston upward to close breaker contacts. At fully closed position a cut-off switch, activated by the breaker linkage, stops the motor. Reset spring in operating cylinder now forces piston downward to return oil to reservoir. The complete operation takes only a few cycles; total system displacement during an operation is only one cubic inch. Operating linkage is disconnected from piston during a mechanical trip-free operation. Fluid system is sealed to reduce maintenance problems.



CLOSED POSITION



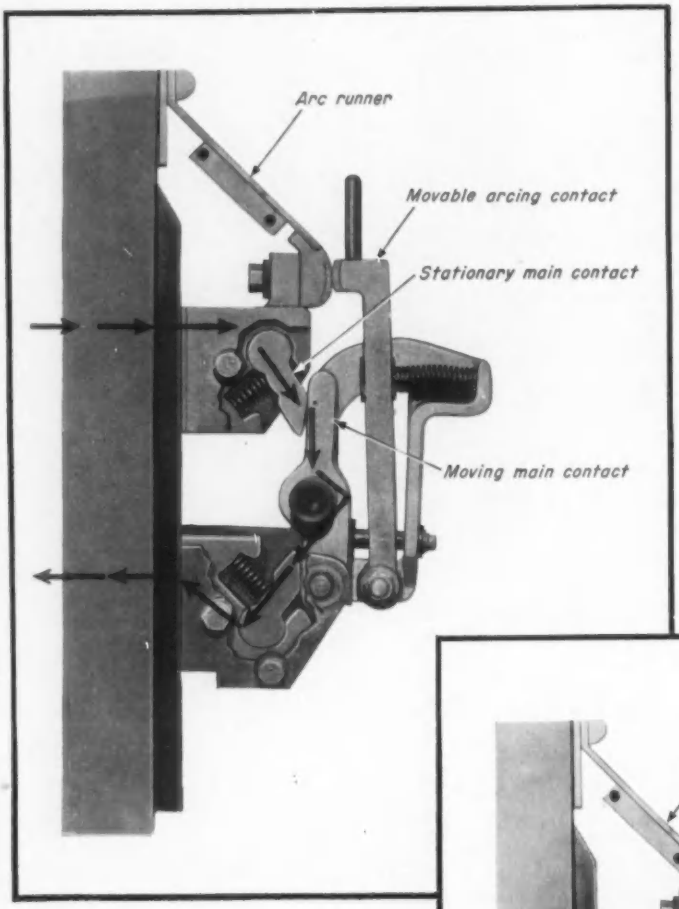
OPEN POSITION



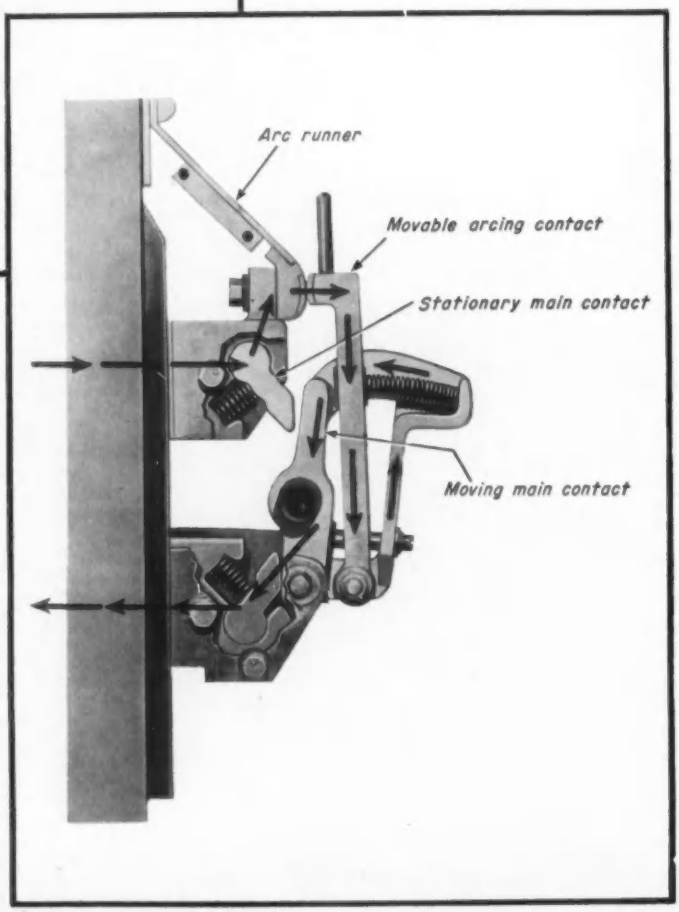
TRIP FREE POSITION

- ● Fixed center
- ○ Movable center
- ◎ Cam roll
- • Fixed to member

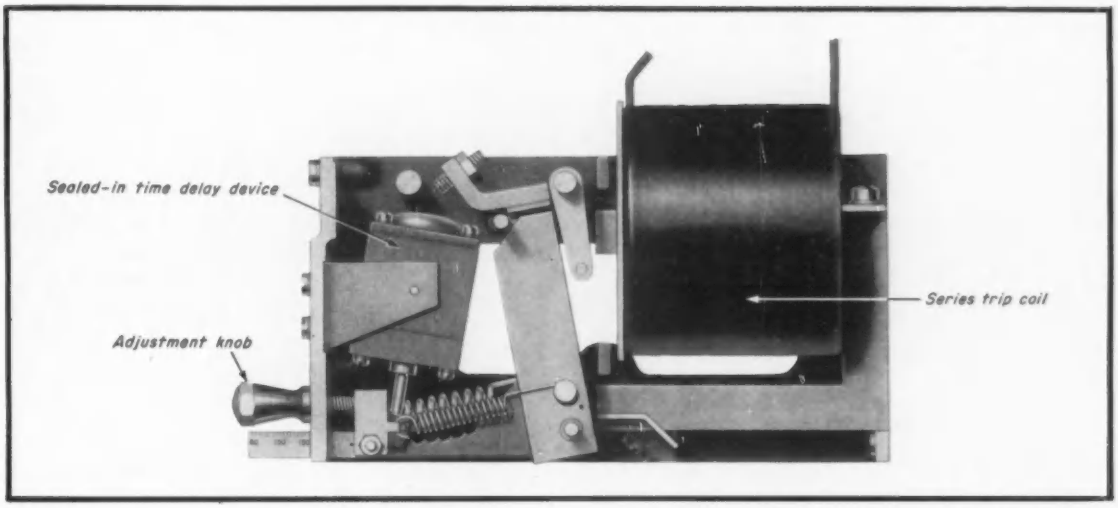
THE SMALLER OPERATING MECHANISM is an important factor in reducing breaker dimensions. This mechanism is shown in three positions. Principal components are a closing cam, which is rotated either manually or electrically, a floating linkage that varies its fixed center on opening or closing, and a load-reducing latching scheme. The closing mechanism cannot be engaged if any tripping means is in control. Pins and latches are high strength alloy steels and precision castings replace intricate machined parts. Prelubricated needle bearings are used at critical points as a few ounces of thrust must trigger several hundred pounds of pressure.



CONTACT STRUCTURE is as shown. Stationary contacts have positive wiping action both in opening and closing to maintain low resistance contact surfaces. The stationary main contacts pivot in mounting socket provided in upper contact block. A wiping high pressure contact is produced by an eccentric configuration on lower end of movable main contact element. Lower contacts touch continuously and take no part in the interrupting sequence. No flexing pigtail conductors are used. Inherent magnetic forces hold contacts together during current surges; thrust of the magnetic fields aids the compression springs to maintain adeqaute contact pressures.



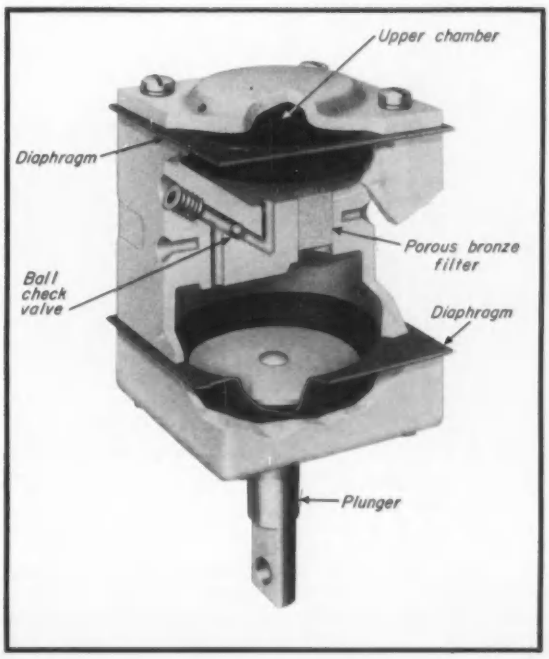
WITH BREAKER IN CLOSED POSITION, current flows through main contacts in a direct simple loop. When breaker opens, current flowing through arcing contacts forms a reverse loop which is superimposed on the simple direct loop. Reversed loop field cancels magnetic effect of direct loop and produces a "blow-on" effect on the arcing contacts. The spring-backed bridging contacts are located on the inside of the corners of the loop so the combined magnetic and spring forces prevent uncontrolled parting. Silver tungsten alloys are used for greater arcing contact life.

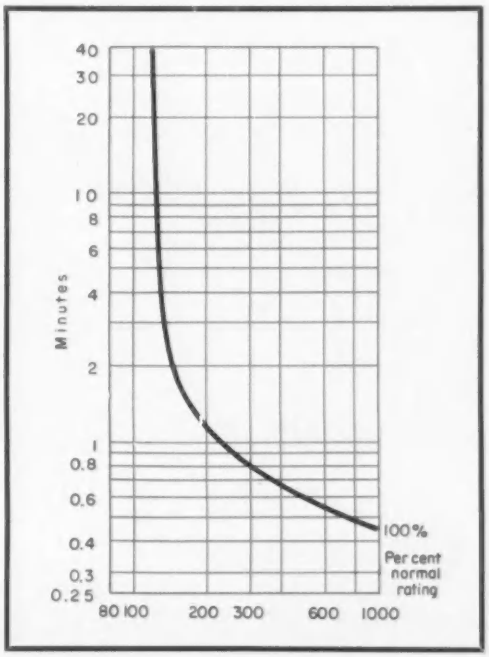


THE DELAY DEVICE has a die-cast zinc body and a plunger which is connected to the moving arm of the magnetic circuit by mechanical linkage. A fixed volume of silicone oil is contained by two flexible diaphragms within the body. Upon a fault condition, the plunger is pressed upward by the series trip device and forces oil into the upper chamber through a porous bronze filter. Plunger resets when fault is removed and oil flows down through ball check valve to normal operating position. The time delay devices are evacuated, filled, sealed and calibrated in manufacture; no field adjustment is required. Time delay is adjusted by changing moment arm lengths in trip linkage.

THE SERIES OVER-CURRENT TRIP UNIT shown is applicable to cascaded and selective tripping systems. Each single phase trip unit includes a series coil, a magnetic circuit with armatures, and one or two sealed time delay devices; individual trip units are mounted on a common base. Long time, short time, and instantaneous trip elements may be combined in any trip unit but act independently. All elements have adjustable pick-up points and are delayed by a positive displacement silicone oil time delay device.

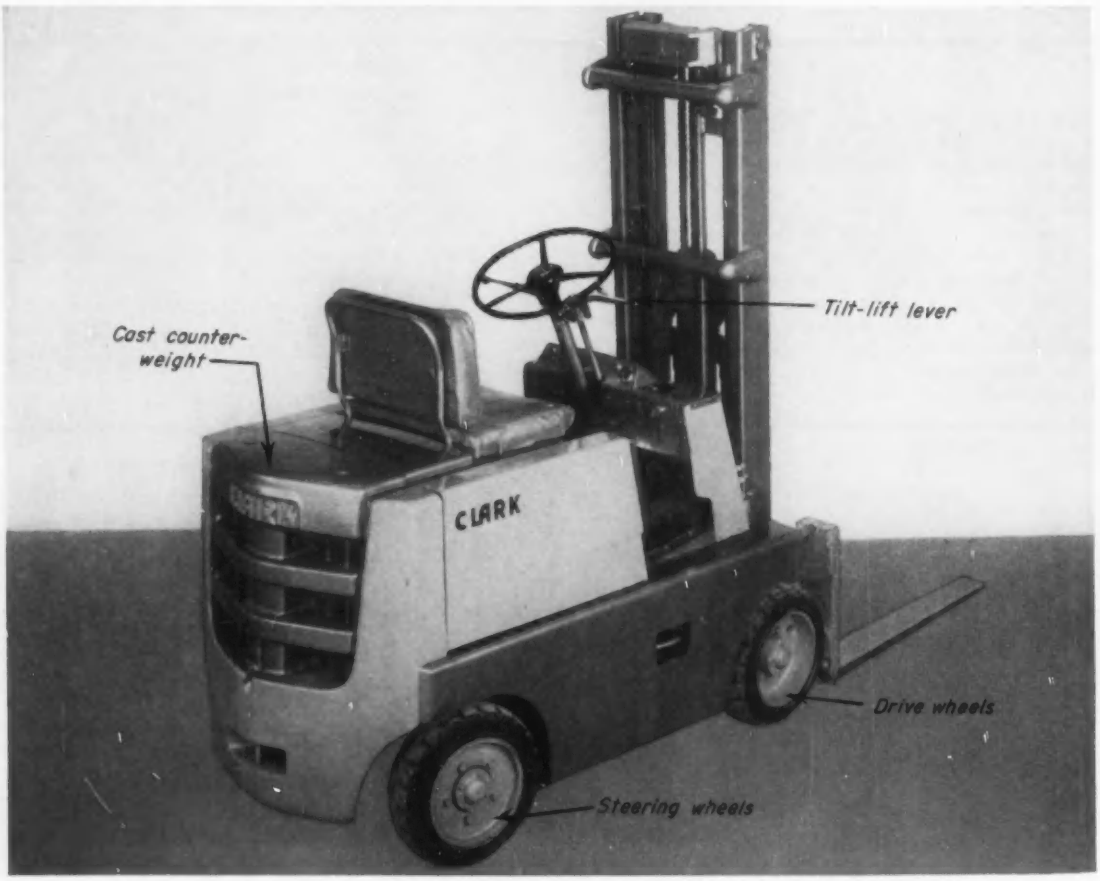
TYPICAL THERMAL TRIP CURVE. Easily adjustable trip characteristics enable breakers to be coordinated with other protective equipment. As trip device is identical for all breakers, curve is typical for all ratings.



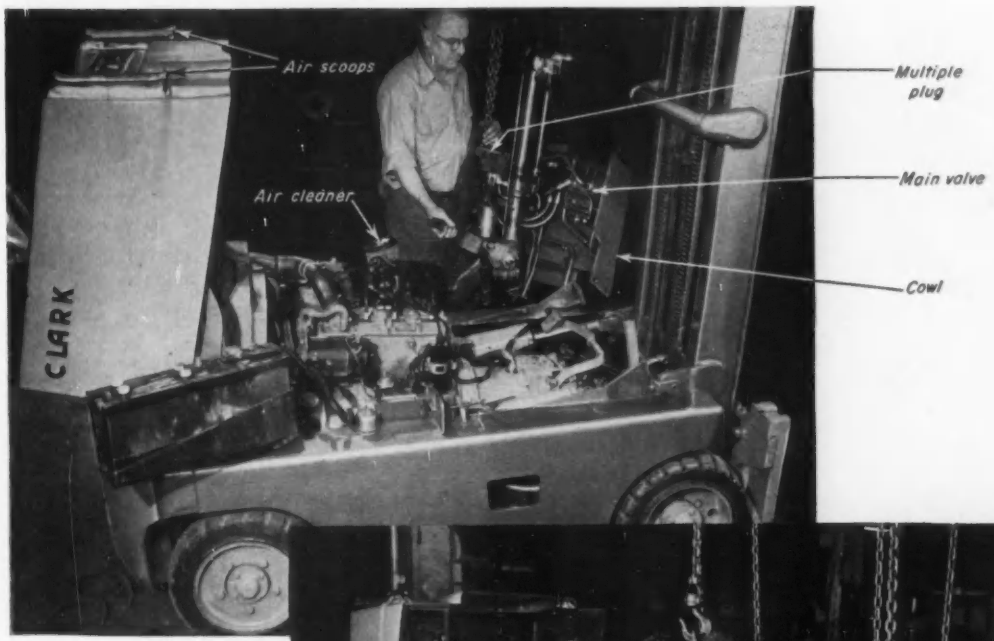


Lift Truck has Sectional Transmission

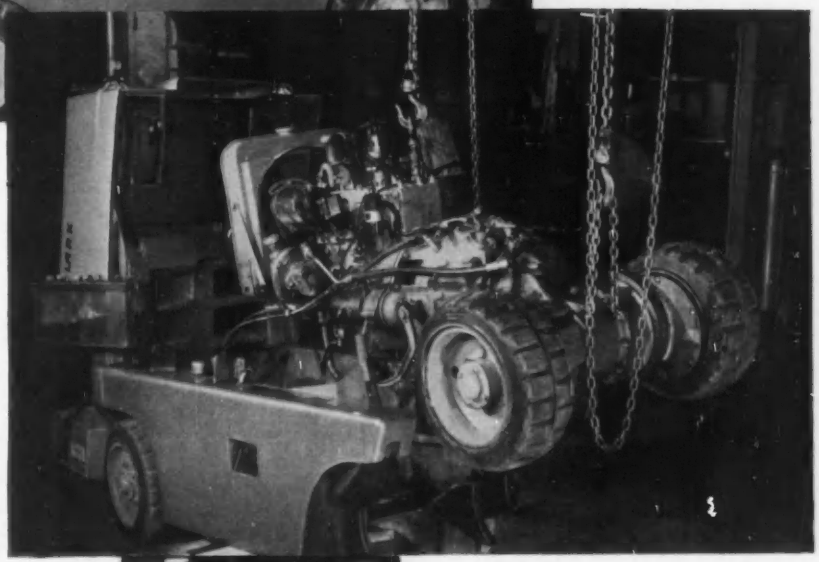
A lift truck line developed by Clark Equipment Co. Industrial Truck Division, Battle Creek, Mich., incorporates an interchangeable transmission, one-lever tilt-lift fork control and a self-adjusting brake that signals lining wear. The hydraulic system includes lock valves for tilt control, a flow regulator for fork lowering, and a cushion valve in the lift cylinder piston to absorb road shock.



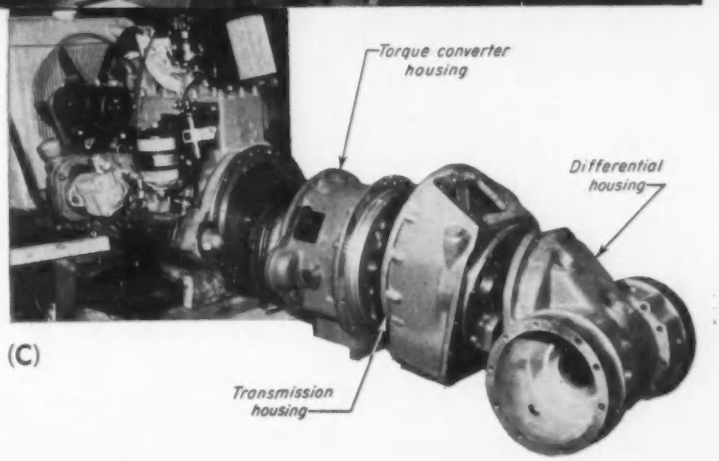
TRUCK is first to have same diameter drive and steering wheels, making for easy maneuverability; conventionally, drive tires are larger. Also, a smaller turning radius is obtained and the required counterweight reduced, as distance from front axle to face of forks is shortened. Much of the counterweight has been placed in front of rear axle, for high traction. The driver seat is spring-loaded; when driver leaves seat, a mechanical brake automatically grabs the differential pinion gear shaft. The fork tilt-lift lever is directional—in and out for tilt, up and down for lift and lower.



(A)



(B)

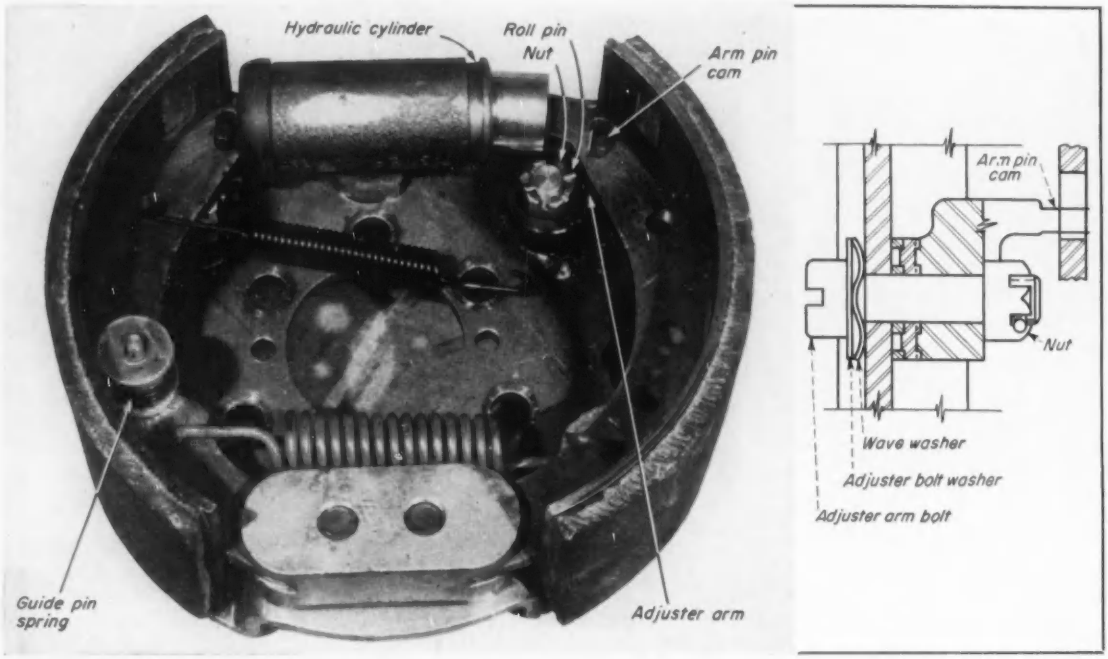


(C)

COWL IS REMOVED (A) by unbolting from frame and by disconnecting associated hydraulic hosing and the multiple-plug under dashboard. Hood is lifted and battery swung out as shown for servicing. Air cleaner is dry-type with pleated paper replacement cartridges.

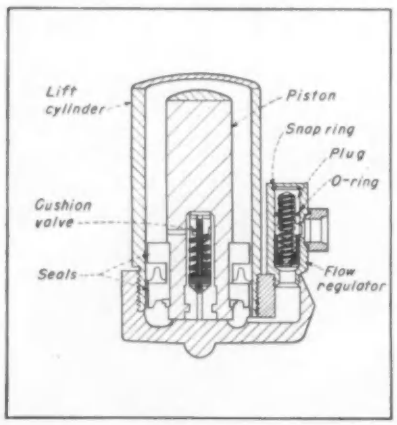
(B) Power train is removed as a unit after disassembling cowl and uprights, and unbolting train from floorboard. Total disassembly time by two men is 75 min. The chassis is welded structural steel.

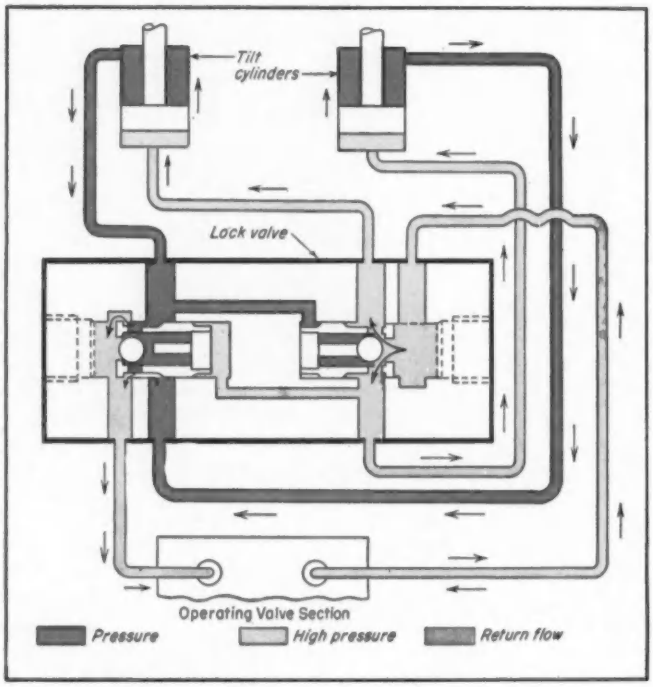
(C) Power train can be unbolted into sections shown. Axle assemblies of different lengths can be inserted into the differential housing, allowing transfer of transmission from one model truck to another.



THE HYDRAULIC BRAKE adjusts with lining wear; the shoes are progressively cam-positioned from center by means of lock washers. When brake is actuated, the arm pin moves with shoe; simultaneously, the adjusting cam is turned. On brake release, washers hold the bolt and the pin at the new position. After lining has worn pre-determined amount, index washer fails to hold arm in the newly advanced position; the resulting soft pedal action signals driver that lining needs replacement.

LIFT CYLINDER INCORPATES a flow regulator. Lowering speed is controlled by regulator plunger which varies outlet orifice; resulting back pressure determines piston speed. A cushion valve is built into lift position.

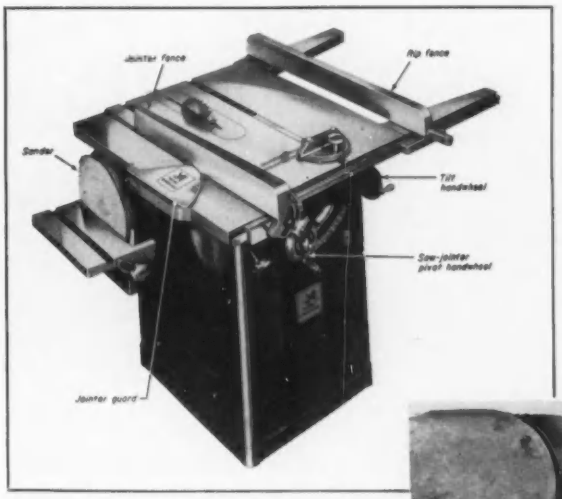


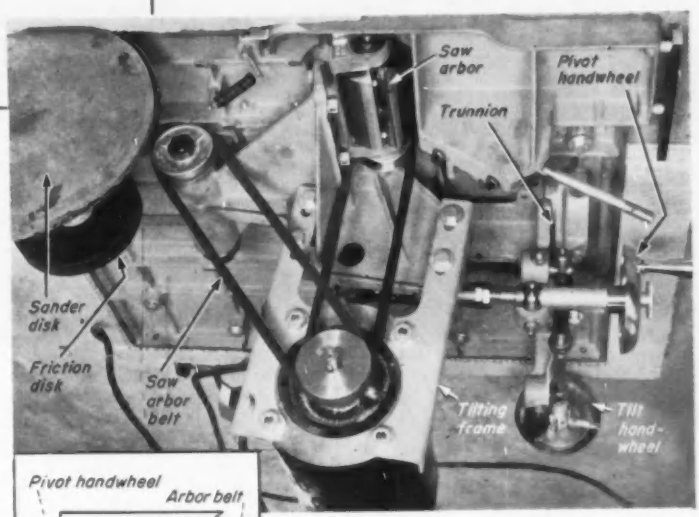


A VICKERS TILT LOCK VALVE prevents run-away piston motion under a load which develops pressure greater than necessary for normal operation. Under this condition, one poppet valve bleeds the other, depending on direction of piston travel. As shown, pistons are driven upward, high pressure oil entering valve at right; oil flowing past poppet at left slowing piston travel.

Multiple-Function Power Tool

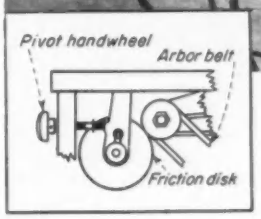
A saw, jointer and sander are combined in a power tool developed by the Yates-American Machine Co, Beloit, Wisc. All three are driven by same motor, saw and jointer through separate belts, sander through friction coupling.



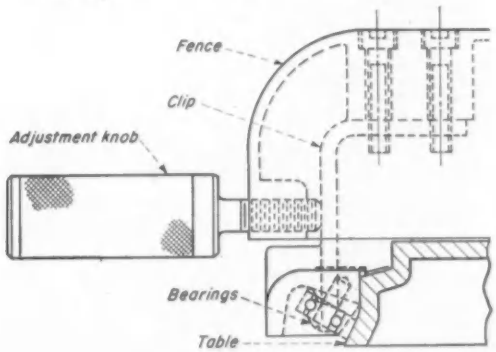


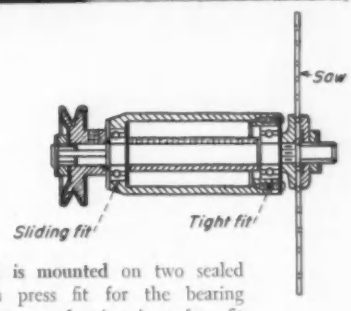
SAW, JOINTER AND MOTOR are mounted on same frame which can be pivoted on shaft or tilted on trunnions. (View is looking up under table.) The assembly is pivoted by a handwheel and screw-driven nut; when saw is up, jointer is down. The assembly is secured by a lock-knob on the handwheel. A second handwheel adjusts tilt, driving a screw which rotates entire assembly through 45 deg.

Sander is driven by heavy rubber friction disk driven by saw arbor belt; disk is engaged by adjusting screw. The sander cannot be operated while saw is in "up" or operating position.



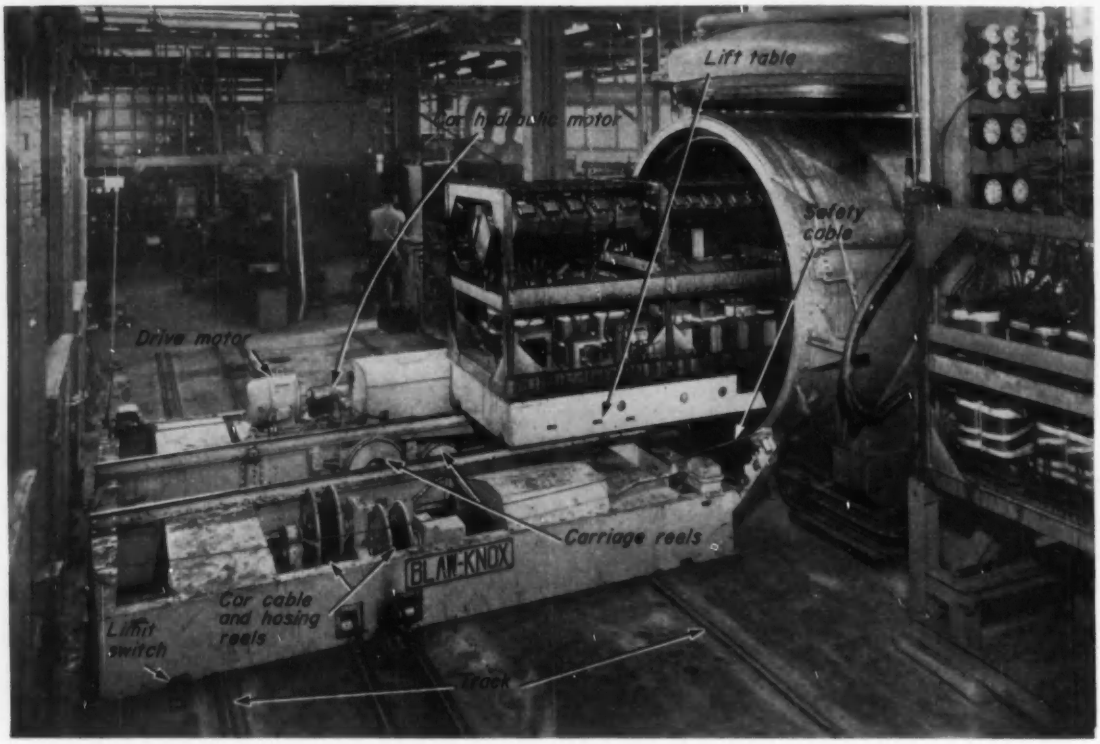
RIP FENCE is mounted on four ball bearings to facilitate sensitive adjustment. Inclined mounting of the bearings reduces tendency of sawdust to adhere to the bearing track. The fence can be removed by lifting, and is locked by turning hand-knob; front and rear guides are secured to the table edge.





THE SAW ARBOR is mounted on two sealed ball bearings with a press fit for the bearing at the saw end. The rear bearing is a free fit to accommodate thermal expansion of arbor.

A three-point probe monitors gear size in an automatic classifier developed by the Michigan Tool Co. of Detroit, Michigan. Previous models used master gears which required production gears to be washed before gaging. Two lower stationary probes and one upper "floating" probe give point contact with the pitch diameter as reference. A geneva mechanism controls and times probe movement and the escapement action that feeds gears to the gaging station.

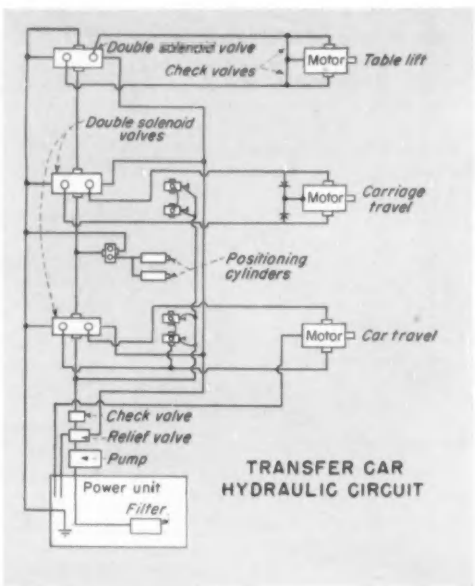


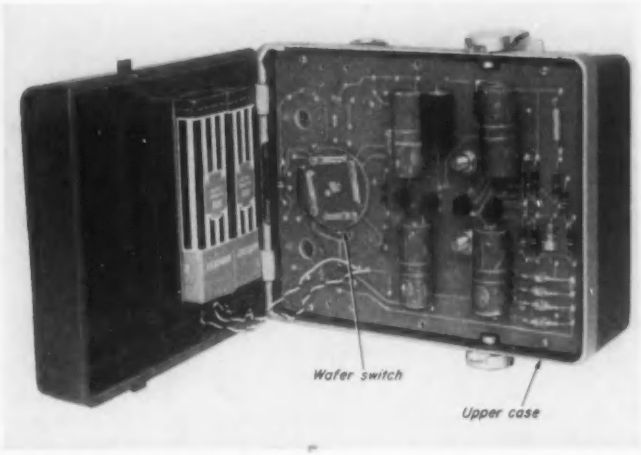
CAR ALLOWS MOVEMENT in six directions. It travels along track between stands, ovens and impregnator; carriage moves transversely to car and lift table mounted on carriage is powered up and down. Unit weighs 100 tons and travels at ½ ft per sec. Operation is controlled by an electrically programmed interlock system; limit switches along rails and on car signal control functions and position the car, carriage and lift table. Each element is driven by a hydraulic vane-type motor; the three hydraulic motors are driven by a 5 hp a-c motor. All carriage wheels are driven to enable carriage to cross 2 ft gap between car and vessel. Worm jacks are used to power table lift. The car is stopped by a magnetic brake.

Driver-Less Automatic Transfer System

A system developed by Blaw-Knox and General Electric engineers automatically impregnates batches of transformers, loaded, transferred and unloaded by an electro-hydraulically controlled car. Designed under supervision of Edward T. Pottmeyer, Blaw-Knox Co., Pittsburgh, Pa., it is used at the GE Specialty Transformer Plant, Fort Wayne, Ind.

SOLENOID VALVES ARE ARRANGED so only one motor can be driven at any given time. Car and carriage hydraulic motors act as pumps after associated solenoid valve is de-energized; the relief valves resist the motor oil return flow, hydraulically decelerating car and carriage. Check valves in table and carriage motor circuits direct motor leakage to return line, eliminating extra drain hosing. Positioning cylinders lock carriage by acting against balls in V-slots in the carrriage frame. Hydraulic drive was used because motors required less space and made explosion-proof system.

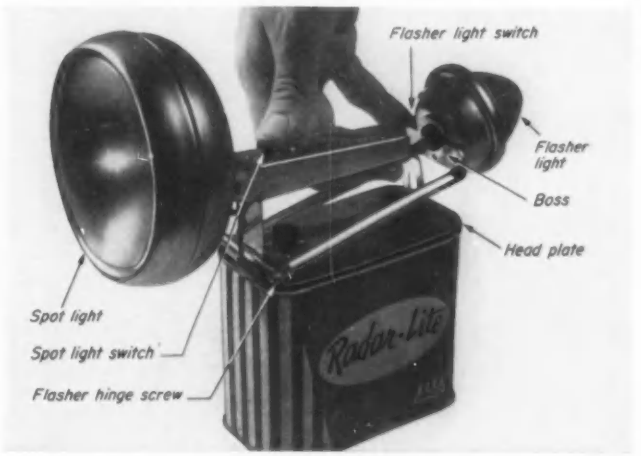




UNIT COMPACTLY HOUSES relatively large capacitors through use of a two-sided etched conductor board. All components are mounted on the board which is assembled to upper half of die-cast case. Heat-sensitive components are soldered with heat-sink pliers. Note etched equivalent to conventional 8-pole, 6-position wafer switch; switch elements and wipers are gold plated. Selector knob (see insert) and indexing mechanism are integral with case; indexing mechanism is spring-loaded in test battery position, so switch, when released, automatically returns to off position to reduce battery drain. Handle pivots to serve as support stand as shown; swung forward, handle acts on a cast latch to unlock the case halves.

All-Transistor Vibration Meter

An all-transistor, battery-operated vibration meter has been developed by Consolidated Electrodynamics Corp., Pasadena, Calif. A two-sided etched conductor board that includes the equivalent of a conventional wafer switch makes possible this compact design.



BRACKET PLATE for the two lights is mounted on and insulated from the battery, with two thumb screws securing the plate at the battery terminals. Lights are separately hinged for independent adjustment; tail light hinge is threaded so hinge screw frictional resistance holds bracket at any angle in 90 deg. swivel range. A boss on the tail light shell engages tail light frame, preventing fastening screw and nut from loosening. Switches are placed to allow simultaneous flipping by hand as shown. Battery contains two cells in parallel; this arrangement gives almost four times the life of a single cell battery.

Case-Less Lantern

No wires need be connected or spring contacts engaged on the Radar-Lite, a lantern manufactured by the Burgess Battery Co., Freeport, Ill. The electrical circuit is made by soldering the light wire to an insulated eyelet which contacts one battery terminal; the other terminal makes contact with the lantern light frame which completes circuit. The steel battery-can serves as a case; top is reinforced for carrying by battery terminals.

Optimum Pressure

for a hydraulic system

CONRAD COOKE
Electro-Mechanical Department
The Glenn L. Martin Company

"What pressure shall I use," the first hydraulic design question, depends on weight, space, power and load requirements, permissible temperature rise, cost and reliability. The statistical method outlined here, while developed for aircraft systems, can be adapted as well to industrial hydraulic systems by a simple alteration in importance factor for each criterion.

Optimum pressure is defined as that system pressure which results in the most ideal combination of design factors, considered in their relative degrees of importance. The analysis involves more than pure mathematics. As an engineering problem it includes determination of data from representative statistics, estimates by leading engineers and, in some places, opinion. Integrity of the results depends heavily on the impartiality of the analyst.

Data, analysis technique and conclusions presented in the following analysis were made for aircraft hydraulic systems, in which the influence of weight, space, power, load requirements, and temperature rise were the only factors considered. While industrial applications place more influence on cost and maintenance, the techniques described are equally effective in weighing these important service and economic factors.

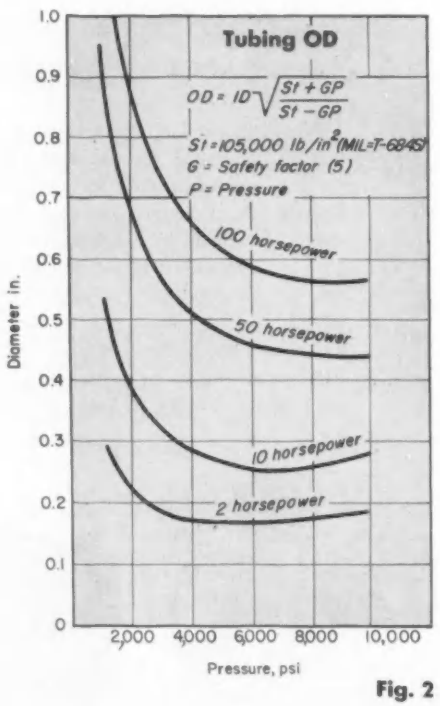


Fig. 2

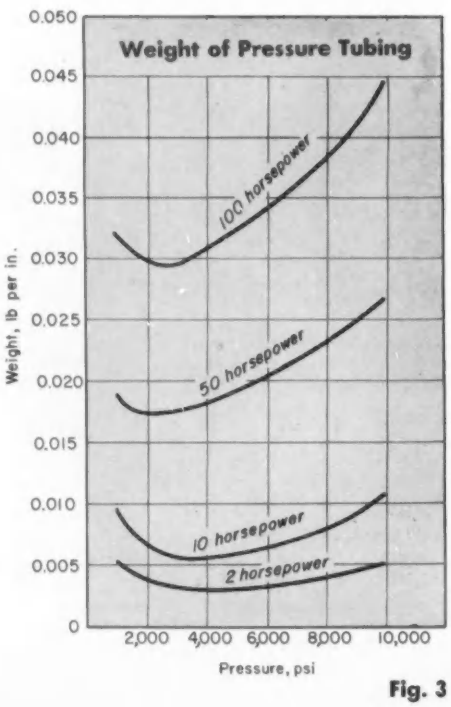


Fig. 3

WEIGHT

Total weight of any hydraulic system may be subdivided into that contributed by the fluid, tubing, fittings, cylinders, valves, reservoirs and pumps. Only a few of these will be discussed here but the method will, with minor modification, serve the other factors as well.

Fluid weight in pressure lines slopes downward with increasing pressure indicating the predominant effect of a reduction of tubing diameter with increase in working pressure. This reduction, as shown in Fig. 1, is permitted in part by the fact that the allowable line loss per running foot (0.383 per cent) can increase with working pressure at constant system efficiency.

By structural analysis of the tubing, curves of tube OD versus pressure may be plotted at each horsepower as shown in Fig. 2. As pressure increases, smaller ID tubing is required to carry the same horsepower and the OD is reduced accordingly. Eventually the growth of wall thickness, especially at low horsepower, becomes more rapid than the reduction of ID.

Resultant tubing weight may now be computed as shown in Fig. 3. Except for scale factor, the curves at various horsepower levels are similar indicating that optimum pressure is relatively independent of horsepower with respect to pressure line tubing.

Statistical data established fitting weight as a function of tubing OD and, combined with the previously derived relationship between OD and pressure, permitted plotting fitting weight versus pressure. Fig. 4 shows the results of this study. Here again curves for various horsepower are similar except for the scale factor indicating an

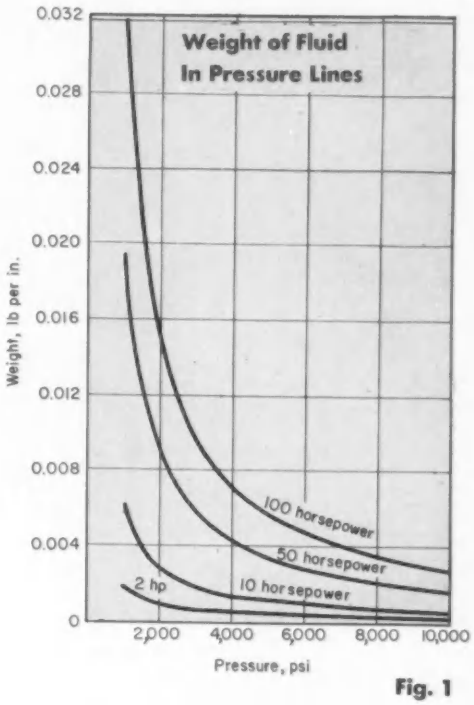


Fig. 1

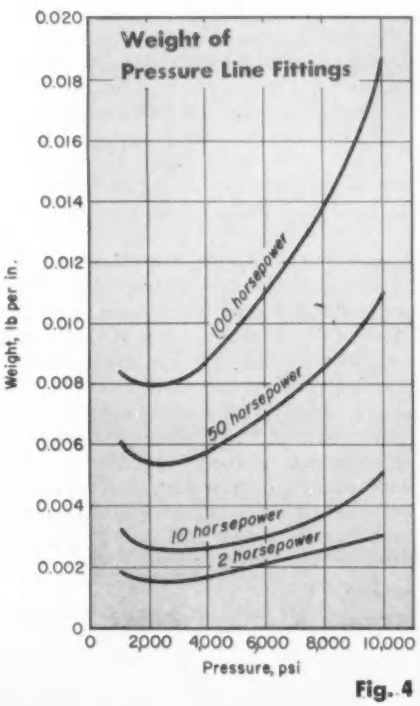


Fig. 4

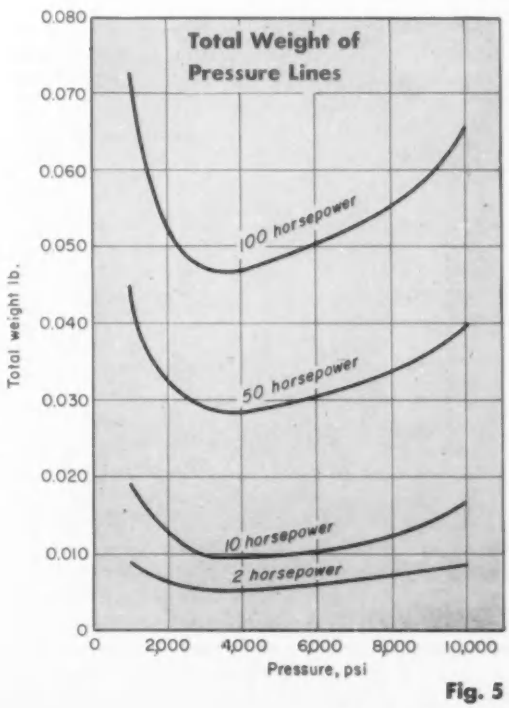


Fig. 5

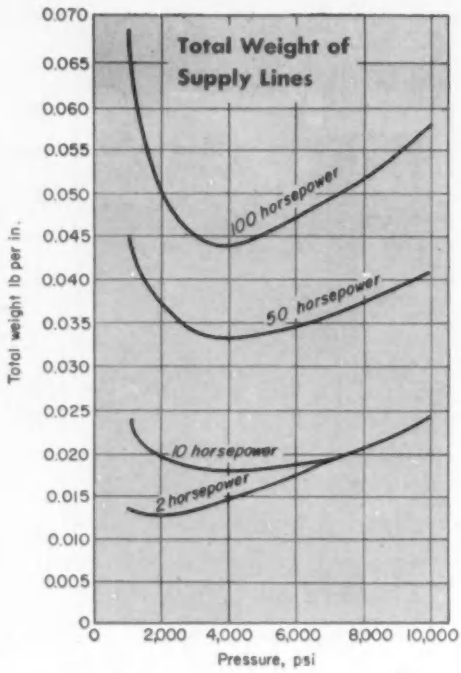


Fig. 6

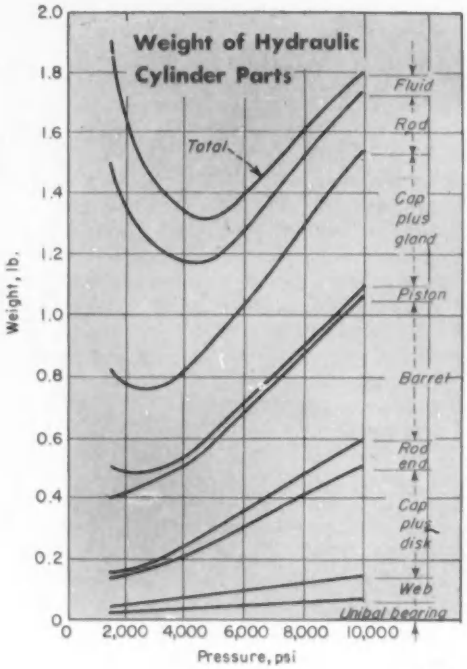


Fig. 7

optimum pressure between 2500 and 3000 psi for minimum weight per inch of pressure line fittings.

Summing weight per running inch for fluid, tubing and fittings provides a clear determination of optimum pressure for pressure line plumbing. In Fig. 5 curves of all horsepower reach a minimum very close to 4000 psi.

By a similar procedure total weight curves were developed for return lines and for supply lines as shown in Fig. 6. Minimum practical size limitations distort the 2 hp curve from the theoretical pattern, however, optimum pressure indicated for supply lines averages 3700 psi.

Hydraulic cylinders make up a large portion of the system weight and accordingly were analysed in considerable detail. A typical cylinder may be broken down into simple structural components for the purpose of developing a theoretical expression for the weight as a function of system pressure and cylinder work. This breakdown is plotted in Fig. 7 for 20,000 lb-in. work and the total weight for various work outputs is plotted in Fig. 8. Optimum pressure with respect to cylinder weight varies from 5000 psi for the 3000 inch pound size to 3200 for the 100,000 inch pound size.

When considered as a group the assortment of valves in a hydraulic system are important because of the large quantity involved. The check valve is representative, and by consideration of it as an assembly of simple elements curves of weight versus pressure may be derived as shown in Fig. 9.

In the previous analysis, selection of materials was made on the basis of current design practice determined in an industry-wide survey. However, to allow for possible advancement and for known high temperature design changes an analysis was conducted to determine the effect of substitution of new materials. Fig. 10 includes some of the results of this analysis. Titanium alloys show a distinct advantage here.

Having analyzed the individual hydraulic components it is necessary to establish the relative proportions of these

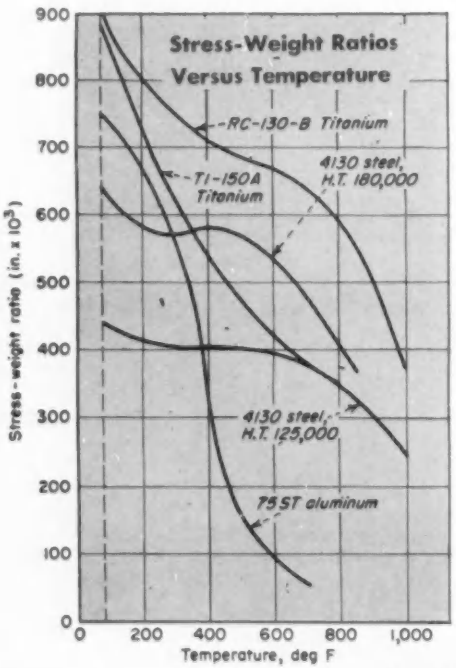


Fig. 10

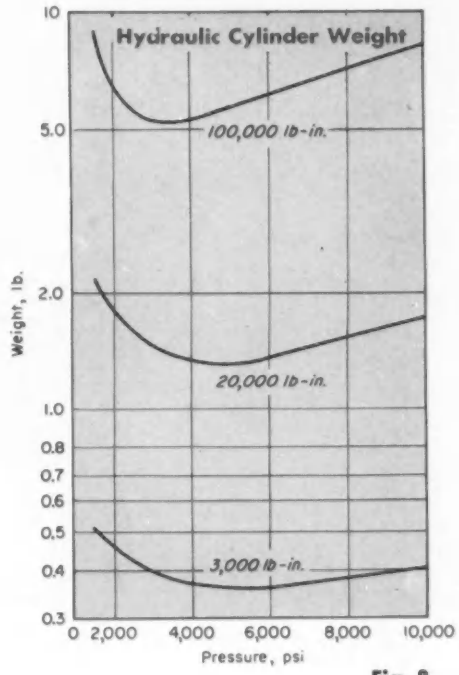


Fig. 8

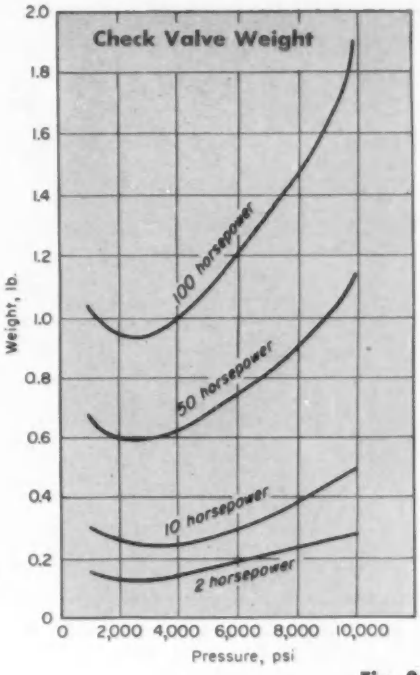


Fig. 9

elements in the system. A survey was conducted to determine the sizes, types and proportions of existing and contemplated aircraft systems and for a typical system the weight breakdown is shown in Fig. 11.

Pump and accumulator weight are independent of pressure. Valves and cylinders both tend to produce low optimum pressures, an effect compensated somewhat by reservoir weight. The four uppermost curves represent weight with various plumbing conditions. The optimum pressure is the same for all of these since the characteristics of plumbing weight are similar to the total system weight without plumbing.

SPACE

Occupied volume is of reduced importance in industrial applications, though the trend toward higher density aircraft for efficient aerodynamic performance at high speeds emphasizes it in these applications.

By methods similar to those used in the weight analysis total space of pressure lines, return lines, valves and cylinders was derived and plotted as a function of system pressure. A typical system space breakdown is shown in Fig. 12. Optimum pressure is relatively independent of type or size of system when considering space. Theoretical low point is reached around 8000 psi.

CYLINDER STRENGTH

As an indication of the performance requirements of hydraulic cylinders in use today, Fig. 13 is a plot of compression load against stroke for a solid rod at 3000 psi and for hollow rods at higher pressures. The potential region of load and stroke proportions available to the designer is reduced at higher pressures. The diagonals running up to the left represent constant work lines. For example a cylinder requirement of 20,000 inch pounds of work could be met by a 2000 pound load through a 10 in. stroke at 3000 psi, but would require at least 2800 pounds through no more than 7.2 in. at 5000 psi. This trend toward short, fat cylinders increases construction weight and the weight of bearings, driven mechanism, and support structure.

Cylinder deflection, which is defined as the change in length of cylinder caused by a change in external load is plotted in Fig. 14. It depends directly on volumetric displacement which various inversely with working pressure range. The plot shows per cent deflection as a function of pressure using standard fluid.

TEMPERATURE

The problem of temperature control within hydraulic systems has become increasingly important in recent years. System power requirements have increased and the heat liberated has risen accordingly. High powered hydraulic servomechanisms are large heat generators since such devices are in continuous use and because servo valves generate more heat by pressure drop and leakage than do selector valves. In the heat breakdown of a medium aircraft hydraulic system 39.5 per cent was generated at the pump and 40.5 per cent by the flight control valves.

These trends have brought about the development of higher temperature fluids, seals and components. System designers have become increasingly temperature conscious.

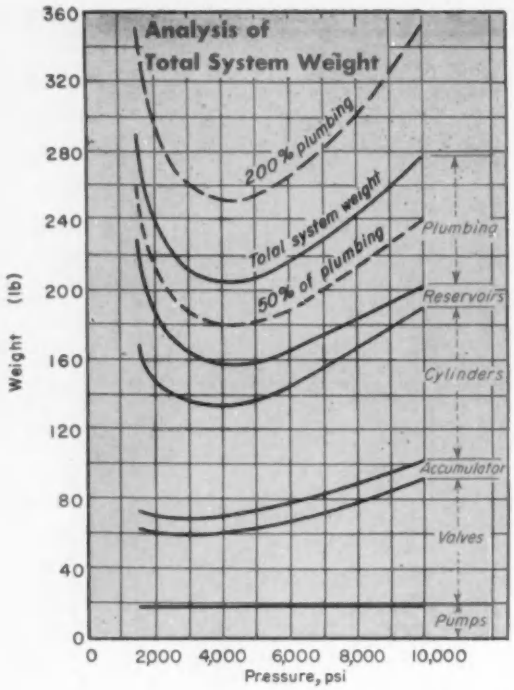


Fig. 11

Fig. 12

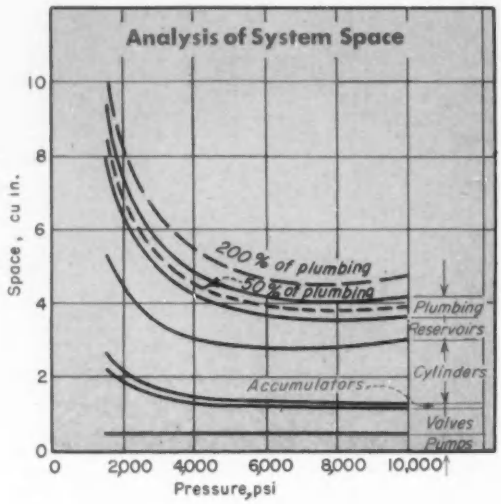


Fig. 15

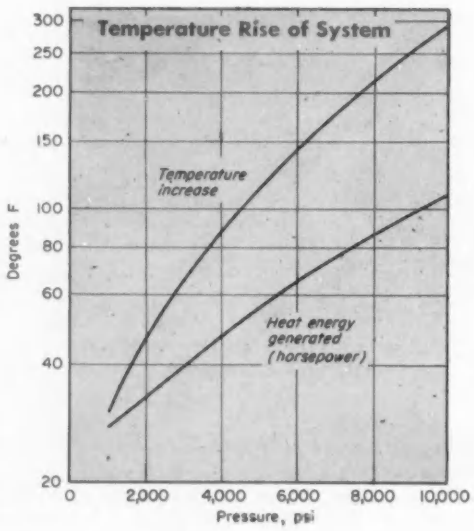
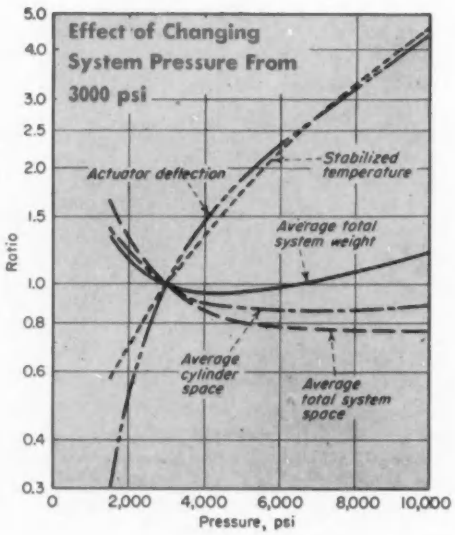


Fig. 16



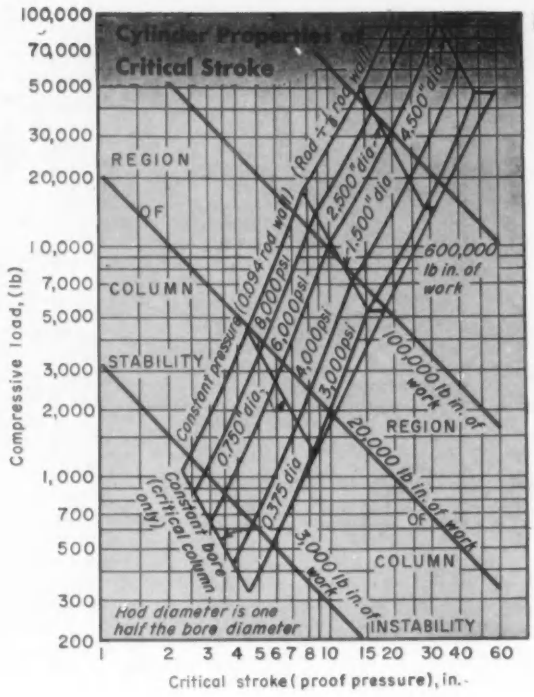


Fig. 13

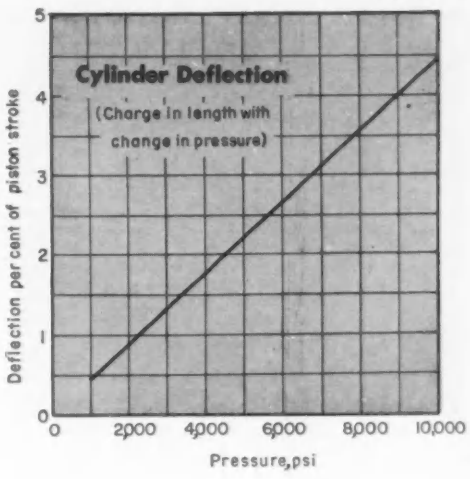


Fig. 14

Mechanical friction and internal leakage are primary factors in pump selection, servo valves are designed and analyzed on the basis of low heat generated, installations provide good convection cooling and supplementary heat transfer units are added where necessary.

A typical system was analyzed to determine the influence of system pressure on the heat problem. As is to be expected, a considerable increase in heat generated occurs at higher pressures as shown in Fig. 15 (lowest curve). This is primarily caused by increased leakage of pumps and control valves. A reduction of external surface area of plumbing and components causes the system stabilization temperature to rise very rapidly in the higher pressure region (upper curve).

COST AND RELIABILITY

In the design and construction of system prototypes, cost is relatively constant as a function of system pressure and has been therefore ignored in this study. Industries which plan large scale duplication of the designed system will have to make careful comparative cost studies to establish the value of optimum system pressure. It is logical to assume that for industrial applications cost may very well override all other factors and as such, deserves a detailed study of its own.

When it can be evaluated, reliability is a primary factor to be considered when making any basic decision. Throughout the study, the concept of reliability was incorporated by considering it necessary to maintain an equivalent degree of reliability at all pressures. Reliability is then a fixed requirement rather than a variable factor.

COMBINED EFFECT

Each of the variables previously discussed have been replotted in Fig. 16 so that all curves intersect at 3000 psi. These are the true individual characteristics before any attempt at determining factors to denote the importance of each variable.

To determine the combined effect of all variables, total system weight was permitted to remain unchanged and the other variables were correlated by establishing a factor of importance for each. System space was considered 20 per cent, cylinder space 30 per cent, cylinder deflection 10 per cent, and stabilized temperature increment 10 per cent as important as total system weight. Assignment of these ratios is arbitrary, depending on the judgment of the analyst and will vary with the ultimate purpose of the study.

Each curve in Fig. 16 represents a penalty ratio of the particular variable as compared to its value at 3000 psi. When multiplied by the assigned importance ratios and renormalized to unity at 3000 psi a composite penalty radio is derived and may be plotted as in Fig. 17. This curve represents the final results of the theoretical analysis. Optimum pressure is indicated at the lowest point, consequently the theoretical optimum pressure is at 4000 psi.

Choice of importance factors has considerable effect on the exact location of theoretically optimum pressure, Fig. 18. By eliminating all or some of the factors the composite penalty ratio curve may indicate optimum pressures between 3000 psi and 4400 psi though it should be noted that the maximum reduction in penalty is only about 7.5 per cent.

For aircraft, weight is of prime importance which ex-

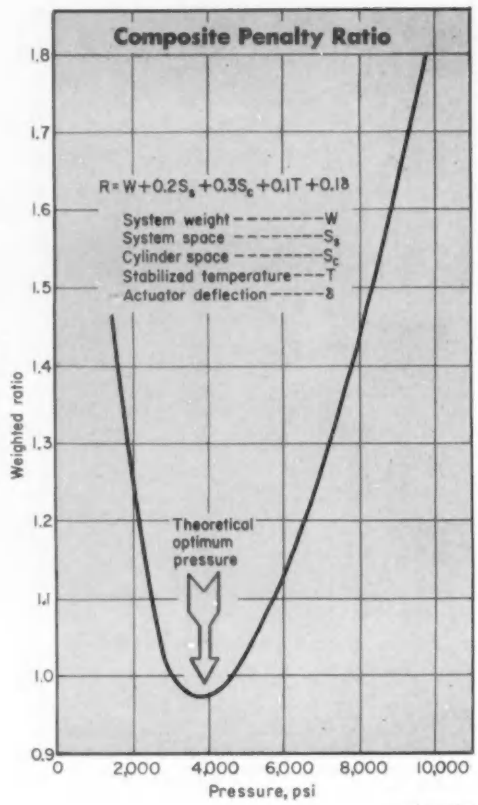


Fig. 17

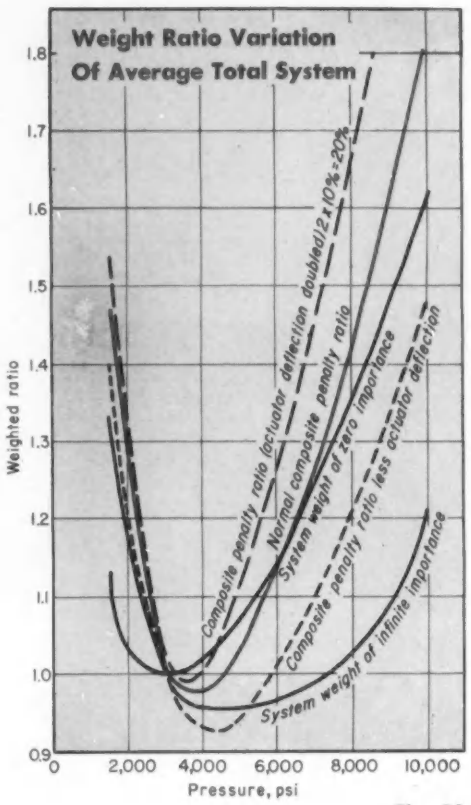


Fig. 18

plains the relatively low importance factors chosen for the other variables. Small changes in the relative importance of the secondary ratios will have little effect on the optimum pressure so that this analysis encompasses a variety of design situations (for aircraft) and there is no need to alter system pressure on an individual system basis. The reduction in penalty if the system were adjusted for each new situation is so small with respect to the penalty, at 4000 psi that consideration of more than one optimum pressure is not justified.

CONCLUSIONS

As a result of the foregoing analysis the following conclusions were reached for aircraft systems. Obviously different applications will alter the picture for industrial systems and cost differentials must have considerable influence on the shape of the resulting curve.

1. Not considering initial cost, the indicated optimum pressure is 4000 psi.

2. The total effective gain in proceeding from 3000 to 4000 psi would be an effective system weight saving of 2½ per cent. Breakdown of this saving is as follows:
   (a) Total system weight reduction of 4.4 per cent.
   (b) Total system space reduction of 13.8 per cent.
   (c) Cylinder space reduction of 10.28 per cent.
   (d) Cylinder deflection increase 44.8 per cent.
   (e) Stabilized system temperature increment increase of 33 per cent.

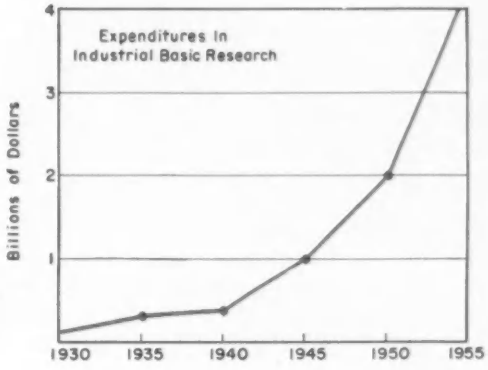
3. The theoretical optimum pressure is fairly independent of the type, size and proportions of hydraulic systems.

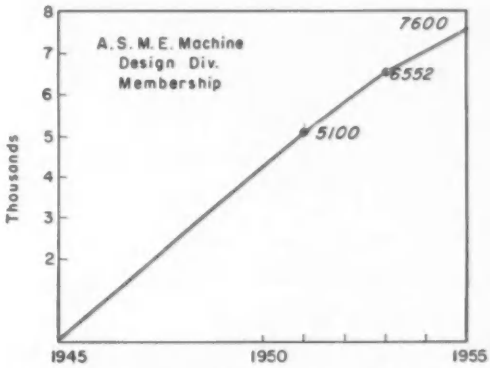
4. A tremendous initial, non-recurring, cost would be required to make a change from 3000 now standard on most aircraft to 4000 psi. This would be necessary for the establishment of new standards, the design and development of new components and test facilities and the procurement and initial training associated with the replacement of all the existing test facilities.

5. A temporary loss in reliability must occur in the transition period during the debugging of newly developed equipment.

6. In the opinion of the author, the small gain of 2½ per cent effective reduction in system weight as itemized above, does not justify the initial cost and temporary loss in reliability which would occur if the standard system pressure were changed to 4000 psi.

Your Guide *at the* *Design Engineering Show*





TOP, curve shows the great increase in funds poured into basic industrial research, the end result being more products to be used by designers. By 1965, estimates place expenditures at $13-billion annually. Below, a reflection of the increasing interest in the design field is the membership trend of the Machine Design Division of the ASME (7,600 as of 1955). This is about 19 per cent of the ASME's total membership.

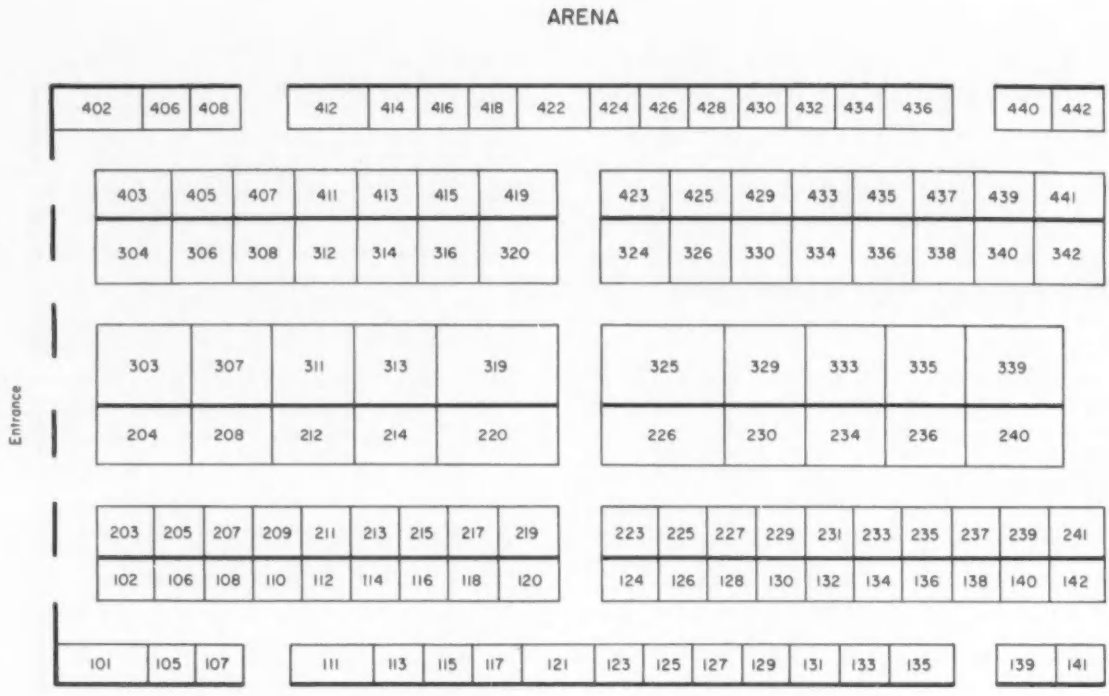
TO HELP LOCATE THE BOOTHS of interest to you at the Design Engineering Show, *Product Engineering* has printed on the next two pages a floor plan of the booths at Convention Hall, plus a complete list of the exhibitors and their booth numbers. This list has been corrected and supplemented with names of the latest additional exhibitors up to the day the magazine went to press. As of this writing, 170 exhibitors have reserved booths at the Show, with several more expected in the next few weeks. Following the floor plan and the list of exhibitors, is the Program and time schedule for the Technical Sessions.

Held this month from the 14th to the 17th at Philadelphia's Convention Hall, the Show is called the First Design Engineering Show because it is the first of its kind ever held. It is a must for all design engineers. It is the only show that has been planned for the designer, so that he will be able to see exhibited at one place all of the materials, finishes, mechanical components, power and control devices, and the latest in production and processing methods which he will be able to specify for his new product. As an aid to the designer attending the Show, each exhibitor will have in attendance engineers from his company to discuss in detail the specifications and characteristics of his new products.

This Design Show is something new and different, and as plans are now set up, it will be repeated each year. According to the Show's managers, Clapp & Poliak, Inc., the response to this type of industrial show is far better than they had anticipated.

Here are some of the products which will be on display at the exhibitors' booths. **Mechanical components:** brakes, bushings, bearings, flexible shafts, lubricating equipment, speed reducers, chains, clutches, springs, transmissions, vibration mountings, servo components, seals, etc. **Engineering Materials:** high alloy steels, clad metals, wrought iron, aluminum alloys, beryllium alloys, brass and bronze, magnesium, metal powders, titanium, bearing alloys, low alloy steels, etc. **Non-metallic:** ceramics, fiber glass, glass, plastics, rubber, silicones, cork, friction materials, and others. **Electrical Components:** connectors, actuators, circuit breakers, electric brakes, electronic tubes, generators, ignition systems, magnets, motors, transistors, timing motors, strain gages, switches, printed circuits, solenoids, transducers, relays, etc. **Hydraulic and Pneumatic components:** air motors, actuators, connectors, valves, pumps, piping, hydraulic fluids, diaphragms, accumulators, hose and tubing, controls, actuators, gaskets, etc. **Finishes and Coatings:** ceramic coatings, clad surfaces, organic coatings, lacquers, mechanical finishes, anodized finishes, paints and varnishes, phosphate coatings, etc. **Fasteners:** clamps, collars, pins, retaining rings, screw fasteners, welding, washers, rivets, nuts, bolts, adhesives, solder, etc. **Shapes and Forms:** brazed assemblies, centrifugal castings, drawn parts, drop and press forgings, metal powder parts, roll-formed parts, sand castings, wire parts, precision investment castings, molded non-metallic parts, spinnings, stampings, punch press parts, etc. **Accessories:** testing machines and equipment, recorders, spectrometers, computers, drafting instruments and supplies, reproduction equipment, transducers, spectrometers, metal reproductions, etc.

The Design Show has the backing of all the leading manufacturers, and the four leading publications in the design engineering field. The magazines: *Product Engineering; Materials & Methods; Machine Design;* and *Electrical Manufacturing* through their chief editors, have been chosen as papers committee for the concurrent ASME Machine Design Conference.



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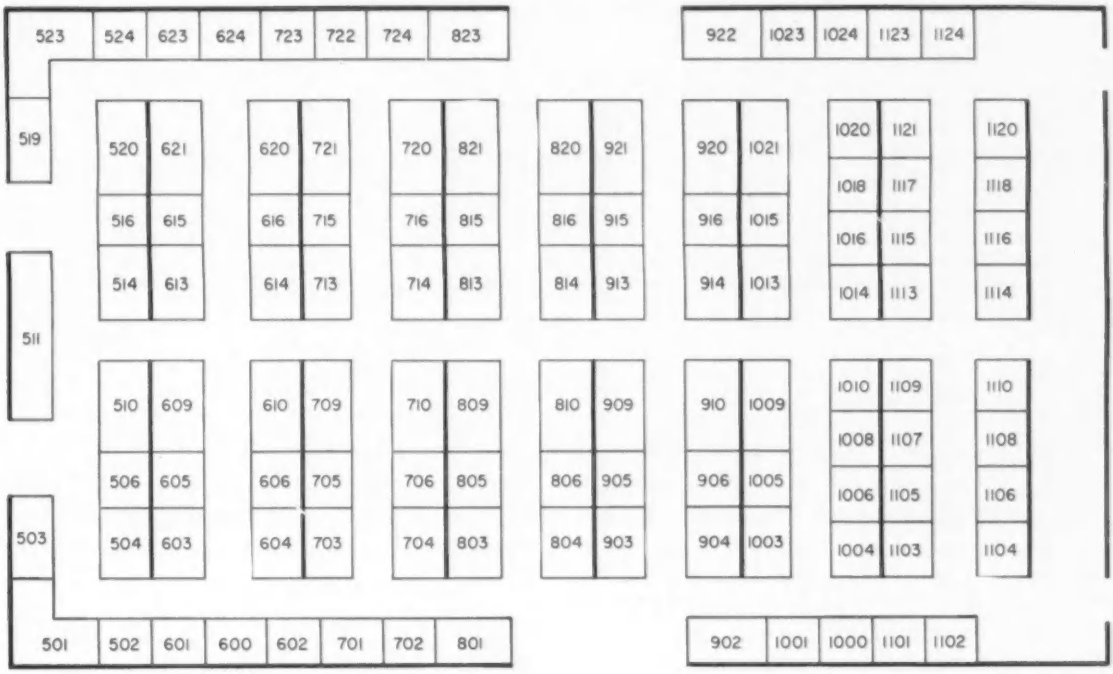

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Design Engineering Conference Program

"Tomorrow's Products Are Tomorrow's Markets"

Convention Hall, Philadelphia, Pa., May 14-17, 1956

Sponsored by the ASME Machine Design Division in cooperation with the Philadelphia Section, ASME, and held in conjunction with the Design Engineering Show.

Monday, May 14—Technical Session I
9:30 a.m., Ballroom

"Value Analysis in Product Design"

A discussion of General Electric's value analysis program; how such a program works; the philosophy behind it; and examples of how cost reductions have been realized through simple redesign of products.

Speakers:

A. D. Bentley, Specialist, Value Analysis Services Section, General Electric Co., Schenectady, N. Y.

W. L. Healey, Supervisor, Data Bureau, Philadelphia Works, General Electric Co., Philadelphia, Pa.

Chairman: Victor F. Sepavich, Dir. of Engineering, Crompton and Knowles Loom Works, Worcester, Mass.

Vice Chairman: H. R. Clauser, Editor, *Materials & Methods*

Tuesday, May 15—Technical Session II
9:30 a.m., Ballroom

A Panel Session: "How to Get and Train Design Engineers"

Three panel members will speak for about 15 min each, following which there will be a panel discussion, and a discussion from the floor.

Speakers:

Chester Linsky, Professor, Dept. of Industrial Engineering, Pennsylvania State University, University Park, Pa.

A. A. Johnson, Manager of Engineering, Switchgear Div., Westinghouse Electric Corp., East Pittsburgh, Pa.

Bernard J. Covner, Assistance Vice-President, Dunlap and Associates, Stamford, Conn.

Chairman: Philip Marvin, Consultant, American Viscose Corp., Philadelphia, Pa.

Vice Chairman: Colin Carmichael, Editor, *Machine Design.*

Wednesday, May 16—Technical Session III
9:30 a.m., Ballroom

"Selecting Engineering Materials for Products"

A check list will be established which the engineer can use to aid him in making intelligent materials selections for his products.

Speaker:

W. A. Irvine, Manager of Production Engineering, The Maytag Co., Newton, Iowa.

"Problems in Miniaturization"

The paper will discuss the methods by which miniaturization can be accomplished, and will show how this step can establish new problems in design and manufacture.

Speaker:

William C. Schmidt, Systems Development Engineer, Merrimack Valley Lab., Bell Telephone Laboratories, Lawrence, Mass.

Chairman: Clifford Eddison, Manager Chemical and Physical Laboratories, Radio Corp. of America, Camden, N. J.

Vice Chairman: Frank Oliver, Editor, *Electrical Manufacturing.*

Thursday, May 17—Technical Session IV
9:30 a.m., Ballroom

"Recognition and Reward for Invention"

How companies encourage inventiveness on the part of their employees. The Westinghouse Electric Corp. Patent Award System will be described.

Speaker:

W. A. Steiger, Manager, Patent Dept., Westinghouse Electric Corp., East Pittsburgh, Pa.

"Rights of the Employee's Invention"

The paper will tell the engineer where his and his company's interests in his work agree, and where they diverge, and what he can do about it.

Speaker:

George V. Woodling, Patent Attorney, Woodling & Krost, Cleveland, Ohio.

Chairman: Donald Fink, Director of Research, Philco Corp., Philadelphia, Pa.

Vice Chairmans Frank Piasecki, President, Piasecki Aircraft Corp., Philadelphia, Pa.

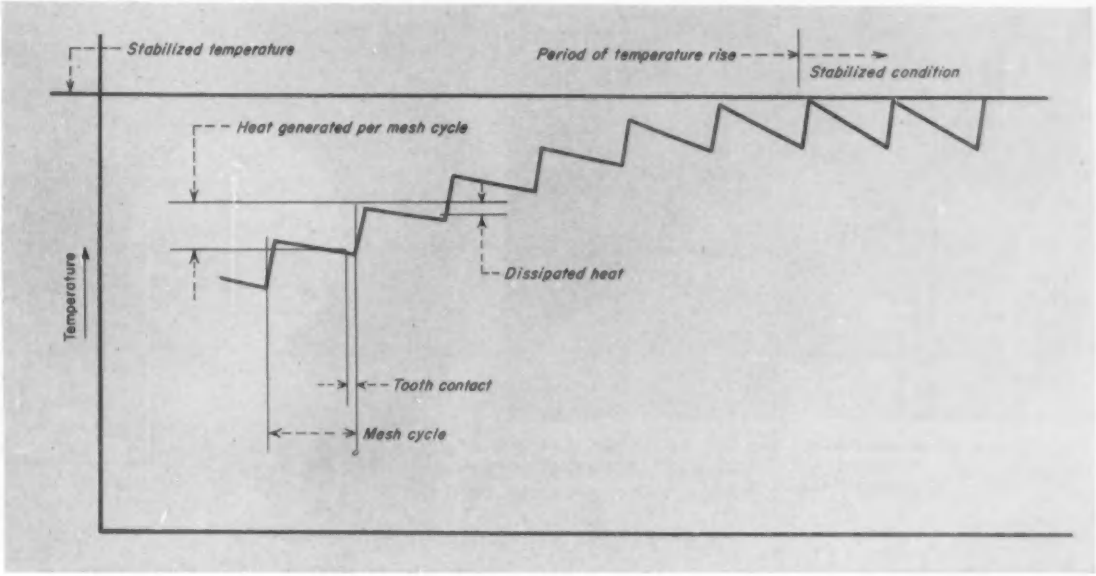


Fig. 1—Theoretical heat cycle for a highly loaded gear tooth. Temperature is a result of high sliding velocities and Hertz stresses.

Lubrication of . . . High Capacity Gear Drives

How to calculate lubrication and cooling requirements, and determine geometry of lubrication system; selection of components to meet system requirements.

D. W. BOTSTIBER
Consulting Engineer and

LEO KINGSTON
Vertol Aircraft Corp.

LUBRICATION SYSTEM for a gear drive of high power capacity cannot be treated as a last minute appendix to a transmission design project. Sliding velocities on the tooth flanks of modern turbine reduction gears and aircraft drive gears may exceed 1200 ft per min. These sliding velocities combined with surface compressive stresses that may be 180,000 psi produce local heat concentrations on the tooth flanks. Fig. 1 shows a theoretical heating cycle for one gear tooth under such conditions.

Some of the heat generated by friction at the tooth flanks will be dissipated by radiation and convection. The remainder will be conducted deeper into the gear blanks and adjoining parts and dissipated from there. For a given system, the amount of heat rejected is a function of the temperature difference and volume of convecting medium. The more compact the unit, the less effective will be radiation and convection to the surrounding air. A major portion of the friction losses must be carried off by cooling oil.

Most high capacity gear drives, including marine, naval, aircraft and industrial reduction and step-up units require pressure lubrication. The design of such a system may be divided into three parts:

1. Determination of over-all geometry of lubrication and cooling system, flow circuit, and components.
2. Determination of sizes and capacities of system and components.
3. Selection of lubricating and cooling oil.

Industrial gear drives of small power capacity were formerly often designed without external cooling. With increasing loads, designers resorted to improved cooling by mounting fans or impellers on the high speed shaft, and sometimes adding fins or shrouds to the housing. By properly shaping the oil sump around the gears, the oil may be guided to continuously flow back towards the gear teeth. The amount of such cooling, by direct convection, however, is small. It can be calculated as follows:

$$Q = \frac{A \times T}{C} \qquad (1)$$

where Q = dissipated heat, BTU/min
A = exposed area of gear case, ft²
T = temperature difference be-

Fig. 2—Gear damage resulting from lack of lubrication. Close-up view, right, of similar type failure shows teeth completely destroyed by lubrication failure.

tween surface of gear case and ambient air
C = 30 for still air
C = 22 for free circulation
C = 10 for forced air flow

Using this formula on high capacity drives, Q will usually be equal to 2-5 per cent of the transmitted power on aircraft gear cases, and 5-15 per cent on marine and general purpose reduction gears.

System Geometry

A pressure oil system consists of a reservoir, pump, heat exchanger and orifices which direct streams of oil to the gear teeth. The oil is heated by contact with the hot surface and drains back into the reservoir. Though this is a simple circuit, it contains all the following variables:

(A)—Total amount of heat to be dissipated.

(B)—Portion of total amount to be dissipated by oil cooler (after allowing for cooling by direct convection through gear case, oil lines, etc.)

(C)—Amount of oil to be circulated (rate of flow).

(D)—Amount of air entrained in the oil during circulation.

(E)—Capacity of reservoir (oil sump) during operation and at standstill.

(F)—Cooling medium.

(G)—Permissible maximum oil temperature.

(H)—Temperature drop through oil cooler.

(I)—Available, permissible, or desirable volume of flow and temperature of cooling medium through oil cooler.

(J)—Characteristics of oil.

(K)—Safety precautions, inspection requirements, unusual operating conditions, weight, size, or cost reductions.

Total amount of heat (A) depends primarily on transmitted power, number of gear meshes, efficiency of gearing and bearing, friction of oil seals, windage and oil churning losses. Usually, it is difficult to separate individual losses. Measurement, even under laboratory conditions, is difficult. If input and output torques were measured, the error would be of the order of magnitude of the losses to be determined. An approximation can be made by measuring the oil flow and temperature drop in the cooler, after insulating the gear case and piping. The values of Table I are adequate for general design conditions of conventional gear drives.

Smooth flanks on the teeth (10 to 30 rms) are important for low friction. If scuff marks or pits are developed, the losses of a given drive may readily be doubled. While the power loss as such may not be important, the cooling system may become inadequate.

The total required cooling capacity of the oil system (B) differs from the total heat generation only by the cooling by direct convection. As mentioned above, this is a small amount and in many instances may be increased by heat from an adjoining prime mover (steam or gas turbine, aircraft engine). This additional heat requires increased cooler capacity.

The rate of oil flow (C), measured by weight, depends upon total heat and temperature drop of oil (temperature difference before and after cooler). For a given system operating at a certain power, this temperature drop is constant.

The mean temperature will rise or

Table I—Heat Losses in Typical Gear Drives

Type of Unit	*Loss per gear mesh—per cent of Power Transmitted*
General machine quality cut gears, sleeve bearings...	1.5–1.8
High quality shaved or ground gears, sleeve bearings..	0.8–1.2
High quality shaved or ground gears, anti-friction bearings, gears in perfect condition.....	0.5–0.7

fall with oil flow and cooler effectiveness. Thus, the flow rate will be determined by allowable maximum temperature, and by size or weight limitations of the cooler. A practical temperature drop is 10-20 C (18-36 F). Based on this, and the estimated generated heat, the pump capacity can be calculated.

Air in the circulating oil (*D*) greatly affects cooling capacity. In comparison to oil, air has virtually no heat exchange value. Therefore, the flow by volume must be increased to compensate for entrained air. The amount of air depends upon sump capacity, internal characteristics of the gear case and flow velocity. The larger the sump, the better the chance for air bubbles to rise to the surface. Smooth internal surfaces and simple shapes will reduce foaming and improve performance. Large openings within the housing must be added for draining oil to the sump. Generally, 10 to 50 per cent of the total flow by volume will be air.

The oil reservoir (*E*) should be as large as practical, and the oil level as far away from the moving parts as possible. The reservoir may consist of the lower part of the gear case (wet sump), or of a separate container connected by adequate piping or by a scavenge pump system (dry sump). Stationary installations have sumps with a capacity of 2-5 times the flow volume per min. Aircraft drives may use oil sumps of only 20 per cent of the flow volume per min. During standstill, oil in the gear case and from cooler and lines may drain into the sump; therefore, the rise of oil level must be considered. On the other hand, a small sump, full at standstill, may run dry in operation and starve the pump.

The choice of the cooling medium (*F*) will depend upon availability. For marine installations, cold water will generally not present any problem. Aircraft gears by necessity use air for cooling. Stationary units vary according to individual merits. A water cooled exchanger is smaller, and piping is usually more convenient than blowers and air ducts. If water is readily available and cheap, the installation is simple; the heated water is piped into the drain. But if the cost of water is high, it may be necessary to recirculate and re-cool. Coolers can be many times larger than the gear case and they must be located to allow for ample air movement.

Physical Data and Average Design Values for High Capacity Gear Lube Systems

Oil Sump Temperature	70–100 C (160–212 F)
Specific Heat of Oil	0.42 BTU/lb/F
Specific Weight of Oil	7.2 lb/gal
Heat Rejection by Outside Convection (% of total)	2–15 per cent
Friction Losses	See Table I
Temperature Drop Through Cooler	10–20 C, 18–36 F
Air Entrainment in Oil Circuit	10–50 per cent
Sump Capacity	1/5 to 5 × Flow Rate/min
Max Oil Temperature	230 C, 450 F
Min Cooling Water Temperature	1 C, 34 F
Min Air Temperature (Arctic Operation)	54 C, 122 F
Max Ambient Air Temperature (Climatic)	50 C, 122 F
Spec Weight of Air at Sea Level and 100 F	0.070 lb/cu ft
Spec Weight of Air at Sea Level and 59 F	0.765 lb/cu ft
Spec Weight of Air at 10,000 ft with 59 F at S/L	0.0565 lb/cu ft
Temp at 10,000 ft when 59 F at Sea Level	24 F
Flash Point of Oil per MIL-L-6082B	216 C, 420 F
Congealing Point of Oil per MIL-L-6082B	−18 C, 0 F
Congealing Point of Oil per MIL-L-7808B	Below −54 C, −65 F
Operating Oil Pressure at Jet Inlet	15–50 psi
Min Jet Orifice Dia for Gears	0.060 in.

For marine installations, salt water corrosion must be considered. Cooling water temperature will vary from slightly below freezing up to about 40 C (104 F) in tropical waters. Aircraft gears may operate in arctic air of −54 C (−65 F) and in tropical air of up to 50 C (122 F), and at atmospheric pressures from sea level to 50,000 ft, with rapid changes.

Operating temperatures of the oil (G) will affect the design in several ways. The higher the temperature, the more effective the transfer of heat, resulting in a smaller cooling system. The limit is established first by the maximum temperature at which the tooth flanks can withstand their loads. For a highly loaded gear, operating with 150,000 psi Hertz stress ("K"—factor of 700), and pitch line velocity about 5000 fpm, tooth flank temperature at time of mesh is estimated at approximately 450 F (230 C). An increase in temperature would decrease the strength of the gear material, leading to scuffing of the tooth flanks, softening and plastic flow of the tooth material and as shown in Fig. 2, eventual failure.

Non-metallic components of the gear case and cooling system may also limit the oil temperature. Many materials now used for gaskets, seals, packings and similar components cannot operate continuously at temperatures exceeding 100 C (212 F). Also, metallic components, housings, bearing retainers, long shafts or large gears of thin cross sections may be subject to heat distortions. This will be particularly pronounced on aircraft gears with aluminum or magnesium housings.

Stationary reduction gears are usually operated with oil temperature after cooler of 70 C (158 F). Marine and naval gears may operate at similar temperatures during cruising and up to 90 C (194 F) in high speed runs. Temperature of aircraft gears during maximum power (except take-off) may be 90-110 C (194-230 F). Maximum permissible oil temperature must be based on operation at the most unfavorable cooling conditions, that is maximum outside temperature, lowest air flow, lowest air density, etc.

Another limiting factor may be the flash point of the oil or the temperature at which it loses its film strength. Generally, however, the tooth load will set lower limits.

The temperature difference of the

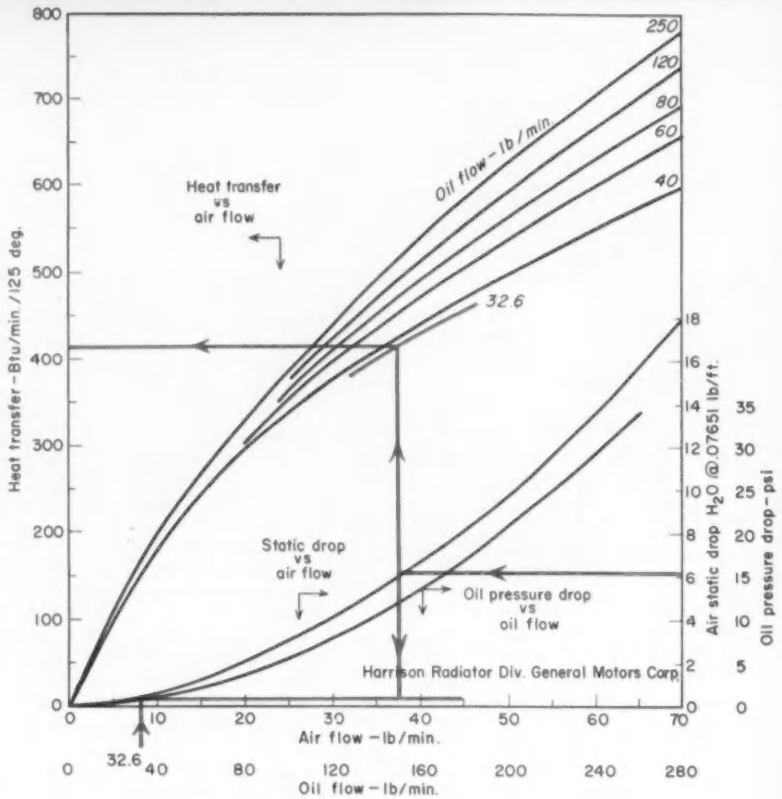


Fig. 3—Typical characteristics for aluminum oil cooler.

oil before and after the cooler (*H*) or, more accurately, between oil sump and lubrication jet inlets, depends on several of the factors discussed previously. Oil flow rate, cooler size, and temperature, specific heat, conductivity, and flow rate of cooling medium are the determining factors. The value of 20 C (36 F), given under (C), is usually a good compromise.

Flow rate and temperature of the cooling medium (*I*) may be determined by external conditions, or may be controllable. Cooling water or air usually must be accepted as is, and the least favorable condition used for determining cooler size and flow rate. Stationary units must use cooling water or air temperature based on the hottest day on which operation is expected. Marine and naval drives must contend with the hottest water in which the ship may operate (40 C or 104 F, in the Red Sea). At high altitudes the air has less cooling capacity per volume, but temperature is lower, −40 C (−40 F) at 50,000 ft. Also, the power loss of the engine must be considered unless it is equipped with a supercharger. Designs for military units generally are based on 110 F (43 C) outside air temperature at sea level and corresponding conditions at high altitudes.

Flow volume for water cooled stationary units may be limited by cost of water or by permissible pressure in the cooler. Water pressure must always be lower than oil pressure to prevent water from leaking into the oil. Aircraft air coolers may receive air either from ram pressure or by a separate blower. Axial flow blowers develop pressures of 6 to 8 in. of water. By tapping engine cooling ducts, or other air circuits, 3 to 5 in. of water column usually can be obtained. Flow is then determined by the resistance of the cooler and ducts.

Selection of oil (*J*) is based on operating requirements. Military Specification MIL-L-6086A requires lubricants for gear drives to have adequate lubricating and cooling characteristics, be virtually non-corrosive, and have a flash point of 280-310 F (138-155 C). Oils of the same quality as used on engines are suitable for high capacity gears, and the speed reducer should be operated with the same oil as the prime mover.

Engine oil per MIL-L-6086B, Grade 1065, has about the same viscosity as SAE 30 (62-68 Saybolt at 210 F or 99 C). It remains liquid to about 0F. Its flash point is about 420 F (216 C). For aircraft drives in arctic operation or for other units subject to starting at very low temperatures, synthetic oils per MIL-L-7808 are used. Their flash point is about 350 F and their pour point −75 F. However, they cost about twenty times as much as mineral oils.

For drives that start and stop under

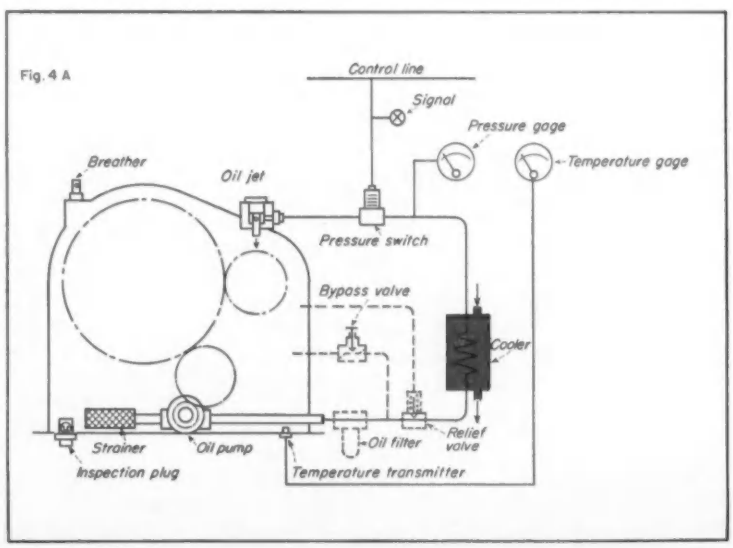


Fig. 4—Typical lubricating oil circuits for industrial gear drive (A) and aircraft gear drive (B). In spite of differences in overall size, shape and weight of the two systems, basic layout and type of components are the same.

full torque, the oil may contain an additive which increases its tendency to adhere to the tooth flanks. This characteristic, "oiliness," is more pronounced with vegetable and animal oils than with mineral oils. Detergents have a similar effect and also tend to decrease foaming. However, additives should be chosen that will not promote corrosion or deterioration of nonmetallic components.

In recent years, many tests have been made with extreme pressure (EP) lubricants. They perform well with hypoid gears, which run with high sliding velocities, but are corrosive to bronze and babbit. This makes them undesirable for worm drives and units with bronze or babbit bearings. Tests on EP lubricants for conventional gears are not consistent, sometimes reporting no improvement. Thus, it seems clear that the choice of lubricant should not influence the design criteria for the gears and that a marginal gear cannot be made safe by any addition to or change of lubricant.

Design Problem

An example of a single gear train will illustrate the factors discussed thus far. A simple planetary unit is to transmit 1000 hp at 1000 rpm input and 250 rpm output.

First, the power loss is estimated. With precision gearing and rolling bearings a simple spur or helical gear train will operate at 0.5 per cent power loss. The potential power of a planetary unit with 4:1 ratio is 150 per cent of transmitted power. The loss then is:

$$H = \frac{1.5 \times 0.5 \times 1000 \times 42.5}{100}$$

$$= 319 \text{ BTU/min}$$

(1 hp = 42.5 BTU/min)

Assuming a maximum permissible temperature of 85 C (185 F), a maximum ambient temperature of 38 C (100 F) and an exposed area of the gear case of 12 sq ft, the heat dissipated by direct convection, Eq (1), is:

$$Q = \frac{A \times T}{C} = \frac{12 \times (185 - 100)}{22} \quad (1)$$

$$= 45 \text{ BTU/min}$$

Thus, 319 − 45 = 274 BTU/min must be dissipated by the cooler. The temperature drop of the oil is taken as 11 C (20 F) and the specific heat of the oil 0.42 BTU/deg F/lb. The flow rate is:

$$F = \frac{\text{BTU/min}}{\Delta T \times \text{spec heat}} = \frac{274}{20(0.42)}$$

$$\frac{\text{lb oil}}{\text{min}} \quad (2)$$

Allowing for 20 per cent entrained air, the flow volume is 32.6 1/2/7/2 = 5.4 gal/min. The characteristics of the oil cooler then determine the oil temperature and air (or water) flow.

Using an oil cooler with the characteristics in Fig. 3 and assuming an available air pressure of 6 in. of water, the airflow is 37.6 lb/min. With the calculated oil flow of 32.6 lb/min, the pressure drop through cooler is approximately 1.0 psi at 225 F for SAE 10 oil. For the oil used, proper correction would have to be made on the basis of viscosity.

$$\frac{P_1}{P_2} = \frac{V_1}{V_2} \quad (3)$$

Where P_1 and P_2 are pressure drops in psi, V_1 and V_2 are viscosities in centipoise.

Extrapolating the data in Fig. 3, the heat transfer for 32.6 lb/min is 4.5 BTU/min/125 F. To apply this to the problem, the following temperature differential will be established for equilibrium conditions:

$$125 \times \frac{274}{415} = 82.5 \text{ F}$$

With an ambient temperature of 100 F, the oil inlet temperature would then be

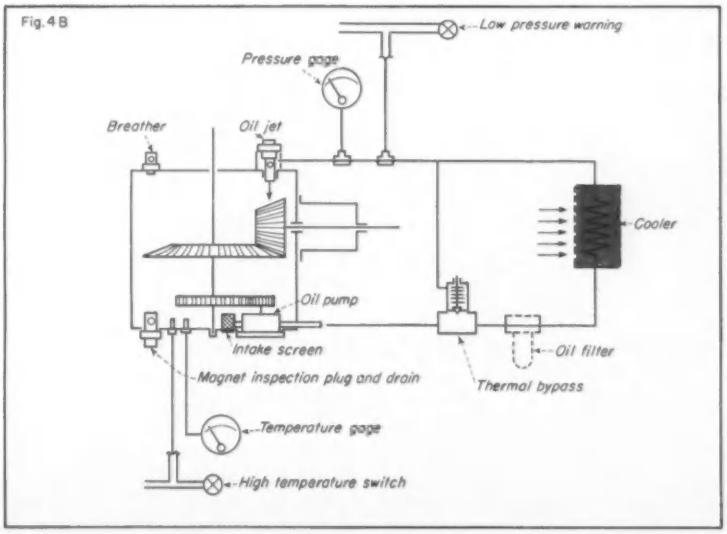
$$100 + 82.5 = 182.5 \text{ F}$$

This is within satisfactory limits of the required temperature. If the calculated temperature were substantially different from the required value, a different cooler might be necessary. Minor differences can be adjusted by changing the oil flow, or by changing air flow through the cooler.

The general arrangement of the oil circuit is simple, Fig. 4. Assuming a wet sump is desired, the lower part of the gear case is used for this purpose. The pump is located near the bottom. It takes the oil in through a strainer, discharges it to the cooler. A pressure relief valve is added in the pressure line when pressure peaks may be frequent and of substantial magnitude. Also, an oil filter may be included. If the pump capacity is substantially greater than the required flow rate, a bypass valve may be used. This should be done only on test installations, since it represents a hazard. In the event of clogging of cooler or jets, the greater part of the flow may go through the bypass, giving only a small pressure rise and starving gears and bearings.

From the cooler, the oil goes to the jets which direct it to the gears. The spray should strike the unmeshing side of the teeth favoring the pinion. Small pinions should be struck by the oil stream radially.

Fig. 4 B



Selection of Components

Oil Pump. Because of the need for continuous flow of oil under pressure, the pump should be a positive displacement type. Its drive should

be mechanically positive. Shear pins or other torque limiting elements, designed to protect the pump from overload, should be avoided. They would save the pump at the expense of the gears. The pump should be near the bottom of the sump, with as little suction required for the intake as possible. Although most positive displacement pumps will develop a vacuum of 27 to 29 in. (mercury), this may be insufficient at low temperatures with ordinary oils, a clogged strainer, or with leaks in the suction line.

A good operating pressure range is 45 to 75 psi, but the pump should be capable of withstanding peaks of 250 psi. These may occur at sudden starts or at low temperatures with high oil viscosity. Pumps using the gear or sliding vane principle are well suited for this operating range. The gears may be of the external mesh type with extra deep teeth or of the internal mesh type with special tooth forms. Vane type pumps should have positive vane motion.

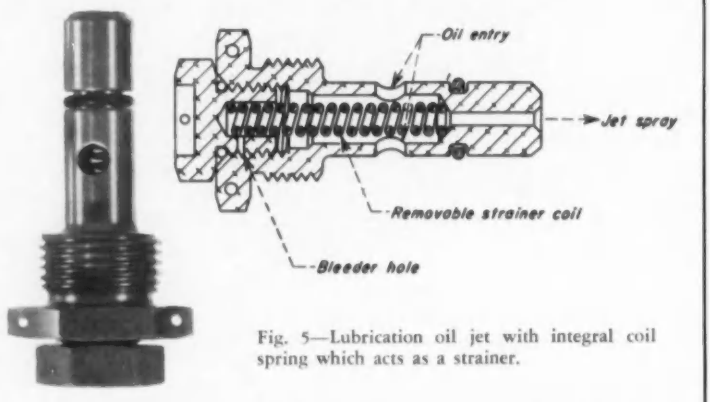


Fig. 5—Lubrication oil jet with integral coil spring which acts as a strainer.

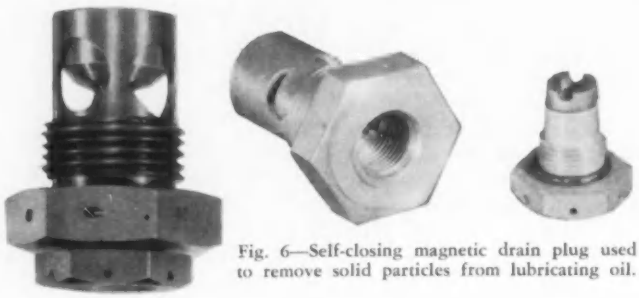


Fig. 6—Self-closing magnetic drain plug used to remove solid particles from lubricating oil.

Intake Strainer. To protect the pump from solid particles, a strainer or screen should be installed at the intake. The size of its openings is a compromise between the filtering requirements and allowable pressure drop .Mesh 20 x 20 with 0.016 in. wire, with total free area of about five times suction line area as proved adequate for most circuits. Area of the intake line should be twice that of the discharge line to allow for the increased volume of entrained air caused by suction.

Discharge Lines. Pipe size is a compromise between economy (size, weight and cost), which calls for smaller lines, and pressure loss which makes it necessary to maintain adequate passages. Oil jets must have positive pressure under the most unfavorable conditions. Generally, 15 psi is the permissible minimum. Losses in the lines should be in the range of 10-40 per cent of the pump pressure. For an average circuit, a flow velocity of about 6 fps is a good initial approximation. Actual losses in the lines may be calculated, based on laminar flow, using the conventional formulas of fluid dynamics.

Pressure Relief Valve. For a normal oil circuit, a relief valve has only limited value. While it may protect the circuit from pressure leaks, it may also eliminate the pressure which otherwise would clear a partially clogged line or cooler, or a pressure rise that would warn of malfunctions. Unless special conditions make a relief valve mandatory, it can be omitted for most circuits.

Thermal Bypass. A bypass is normally closed; at low temperatures it opens and passes oil directly to the jets, bypassing the cooler. As the oil temperature increases, it must close gradually so the oil will apply pressure to the cooler and gradually clear its passages. Units of this type are used mainly in aircraft circuits.

Oil Filter. In principle, a filter is very desirable to remove solid particles from oil. Filters consist of a porous medium in a housing, preferably with provisions for easy replacement when the unit has become saturated. One drawback is the added pressure drop the pump must overcome. As the filter becomes saturated, this pressure increases. A spring-loaded valve, included in the filter housing may then open and bypass the oil around the filter. Putting the filter in the pressure line makes it necessary to first pass the oil particles through the pump which has the closest clearance and therefore is most in need of protection. All this considered, the role of the oil filter is somewhat compromised.

New filters generally have losses of 1.5 psi; their bypass valves open when the pressure across the filter rises to 5 psi. A strainer of 40 x 40 mesh with 0.012 wire will be a suitable compromise if a screen in the pressure line is desired and pressure drop must be low.

Oil Cooler. For a given flow rate and temperature of oil, the heat rejection capacity of a cooler varies with the temperature and flow rate of the cooling medium (air or water). This gives a number of variables, which are determined by tests and plotted on diagrams as systems of

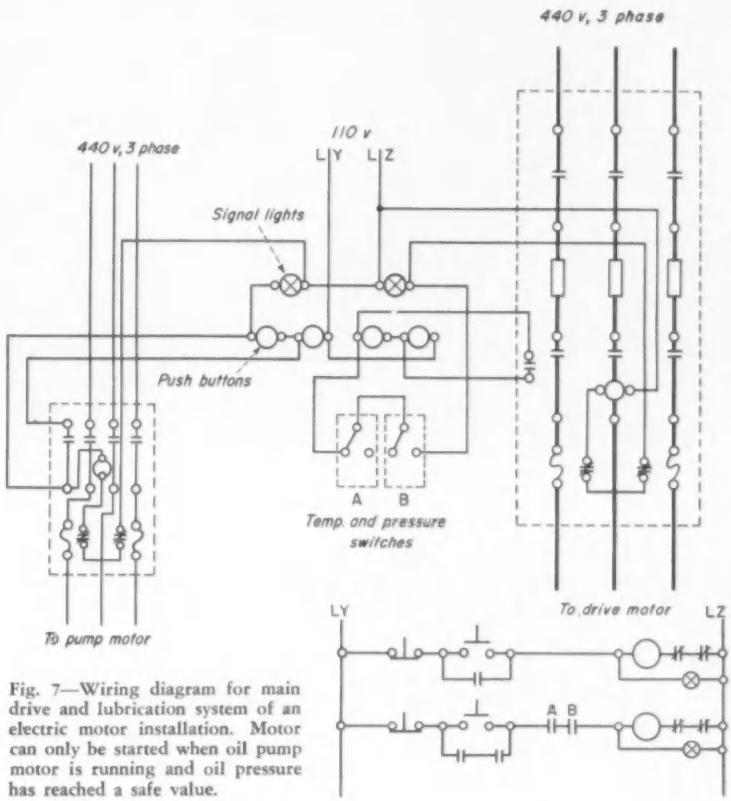


Fig. 7—Wiring diagram for main drive and lubrication system of an electric motor installation. Motor can only be started when oil pump motor is running and oil pressure has reached a safe value.

curves. These data are used as the basis for selecting a cooler for a given application. Usually, the order of magnitude of cooling medium flow by weight is comparable to that of oil flow. That means that if the oil flow is 10 lb/min, an air flow of about 10 lb/min may be expected.

Oil and water should flow in opposite directions since this will keep the temperature difference between oil and water uniform through the cooler.

Oil Jet. Cooled oil is sprayed on the gears through a jet which should produce a solid stream. Velocity of oil leaving the jet must be adequate to reach the gear teeth through the whirling air and penetrate the space between teeth to hit the flanks. Pressures at the jet inlet of 15 to 50 psi are generally satisfactory. The jet orifice must be adequate to pass the required flow. An empirical formula to determine the diameter for round orifices is:

$$F\ (\text{gpm}) = 22\ d^2\ p \qquad (2)$$

where d = jet orifice dia, in.

p = pressure at jet inlet, psi

In general, one jet should be used for every 2 in. of gear face. Using rectangular orifices does not seem to improve cooling or lubrication conditions.

Minimum permissible diameter for a jet is determined by the tendency of clogging from foreign matter. Jets of less than 0.060 in. dia are troublesome. For anti-friction bearings, smaller orifices are sometimes used. They are a compromise between the need for small openings to maintain oil pressure with available flow rates and the small oil requirements of rolling bearings. As shown in Fig. 5, the jet should include an individual strainer to stop foreign matter from reaching the orifice.

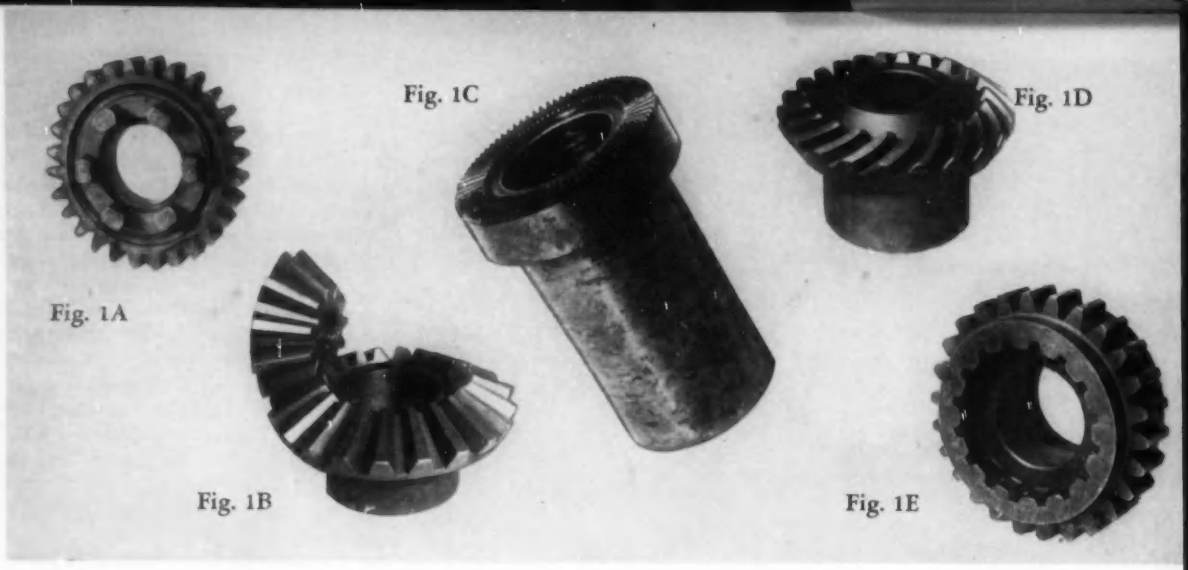
Magnetic Particle Retainer. Since most wear particles are of ferrous material, they can be attracted and retained by a magnet. Located in the oil sump before the pump intake, it can keep these particles from entering the pump. The chief purpose of a magnetic chip retainer is to serve as a warning sign, indicating excessive wear in the early stages. It should be of the self-closing type, so it can be removed regularly for visual inspection without draining the oil, during normal operation. Fig. 6 shows units of this type.

Instrumentation and Warning Signals. The oil circuit affords some means of checking the operation of the drive. Malfunctioning of a gear set or of a bearing is almost invariably evidenced as increased friction and subsequent oil temperature rise. Large gear cases may have temperature gages at each main bearing, to indicate incipient bearing trouble. Normally, it is not practical to measure the temperature at each point of heat generation but only at the sump or reservoir. Even then, an unusual temperature rise will often give advance warning. Pressure gages help warn of clogging of lines, coolers or jets. They also give a general indication of operating characteristics of the system at various conditions of speed, temperature or oil viscosity. If only one pressure gage is used, it should be connected near the jet inlet, since this is the pressure that actually feeds oil to the gears and bearings.

Warning signals may be used to indicate variations of pressure or temperature beyond the satisfactory operating range. Oil pressure drops less than 15 psi near the jets and temperature rise more than 100-120 C (212-248 F) in the sump are usually signalled by electric warning lights.

If the power source is an electric motor or if the oil pump has an electric motor drive, the oil pressure may be used as a signal for readiness to operate. Fig. 7 shows an electric circuit for such a drive. The main motor may only be started when the pump motor is running and oil pressure has risen to the acceptable level. Loss of oil pressure or excessive oil temperature will stop the main drive.

EDITOR'S NOTE—For supplementary data on design of lubrication systems see "Comparison of Six Lubrication Methods," December 1955, page 183. In this article Dr. Beno Sternlicht discusses the characteristics of various methods of lubrication; also included is a guide to the selection of the best method for given requirements.



Finished-Forged Gear Teeth
now used in German Autos

Automobile and agricultural machinery industries in Germany have recently changed to precision-forged gears for the differentials in automobiles, trucks and tractors. All indications point to increased performance with decreased costs. Some of the companies are: The Auto-Union Corp., Düsseldorf (passenger cars and pick-up trucks); Hanomag Corp., Hannover (tractors); International Harvester Company of Germany (agricultural machinery); Fella Feucht Corp., Nürnberg (agricultural machinery); Opel Corp. (passenger cars); Faun Maginus Henschel Bussing (trucks); Maschinenfabrik Augsburg, Nürnberg (trucks); BMW, Munich, (motorcycles).

By a new process developed in Germany, gear teeth are forged to sufficient accuracy to require no machining. Applications include differentials for all types of motor vehicles and other uses where speeds are relatively low. Materials used, accuracy and costs.

O. RIECKHOFF
Chief Engineer
Hanomag Corporation
Hannover, Germany

IDEA OF FORGING TOOTHED PARTS in dies is not new. Patent applications dealing with this subject were made as long as 60 years ago. However, none of these patents lead to the commercial production of finish forged gears. Recently, however, the Bayerische Light-Metal Works, Munich, Germany, developed a process for producing precision-forged gears that can be used in medium-speed applications without machining the gear teeth.

The forging process has been used also for making bevel gears with straight or spiral teeth; hypoid gears; intricate gears which cannot be manufactured by conventional methods, such as elliptical gears, compound spur and bevel gears, and gear sectors. The process is also adaptable for gear parts containing special notches, cam profiles, pads or stops such as shown in Fig. 1.

Table I—Chemical Compositions of German Steels Used for Precision-Forged Gears

German Designation	Carbon C	Silicon Si	Manganese Mn	Chromium Cr	Nickel Ni
CK 45	0.42–0.50	0.25–0.50	0.50–0.80	.....	.....
EC 60	0.12–0.18	0.15–0.35	0.40–0.60	0.50–0.80	.....
EC 80	0.14–0.19	0.15–0.35	1.50–1.30	0.80–1.10	.....
EC 100	0.17–0.22	0.15–0.35	1.10–1.40	1.00–1.30	.....
15 CrNi 6	0.12–0.17	0.15–0.35	0.40–0.60	1.40–1.70	1.40–1.70

The Forging Process

First step in the process is machining the gear blank to predetermined volume (*B* in Fig. 2). This operation also removes surface oxides or scale. The blank is made so that the direc-

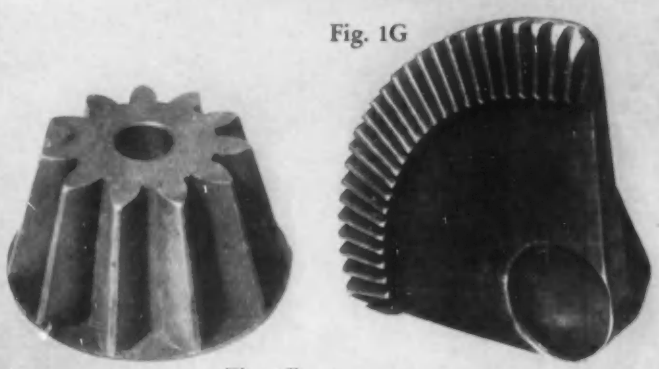


Fig. 1G

Fig. 1F

Fig. 1 — Typical gear parts made by the precision-forging process. (A) Spur gear with cogs, (B) bevel gears for differentials, (C) toothed bushing, (D) spiral bevel gear, (E) spur gear with internal spline, (F) flanged bevel gear, and (G) steering segment.

tion of the grain or fiber of its metal will be parallel to the direction of the stroke of the press during the forging operation. The machined blank is then heated to about 3000 F in an inert gas atmosphere to prevent the formation of scale. It is then squeezed into the die cavity by a mechanical press in two or more strokes, depending on the size of the blank. Immediately after the forging operation, the blanks are coiled, again keeping them free from contact with the air, and slightly tempered.

Gear Materials

Many types of steel, including high alloy tool steel, and a number of nonferrous metals have been precision forged successfully by this process. Gears thus produced have an improved grain structure and thereby harder and stronger teeth. This accounts for the higher static strength of these forged teeth as compared to cut teeth of the same material. Fig. 3 shows the grain structure of a chromium-steel ratchet tooth after forging. Table I lists the chemical compositions of some of the steels successfully used for forged gears.

Accuracy of the gear teeth is fundamentally dependent upon the accuracy of the forging die. The required precision of the die is obtained by mechanically and chemically copying it from a hardened and ground master gear, the dimensions of which have been modified to allow for shrinkages during the forging and heat-treating operations.

Accuracy of Gear Teeth

Inaccuracies in the forged tooth profile stem from the impossibility of compensating exactly in the master gear for the variable shrinkages that occur during the process. Even so,

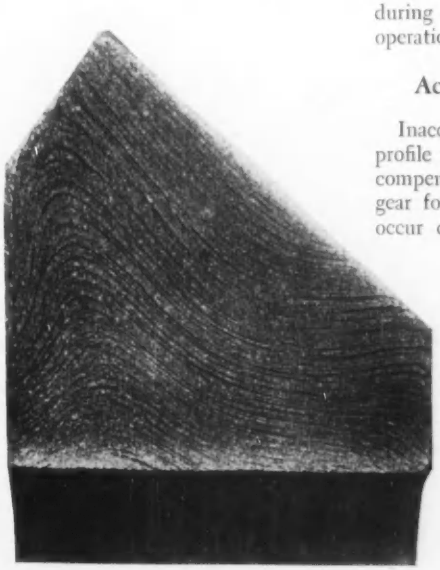


Fig. 3—Grain structure of a ratchet tooth after forging resulting in a 20 per cent greater tooth strength than machined gears of same material. Material is EC-100 chromium steel.

Fig. 2—Operations in producing a precision-forged gear.

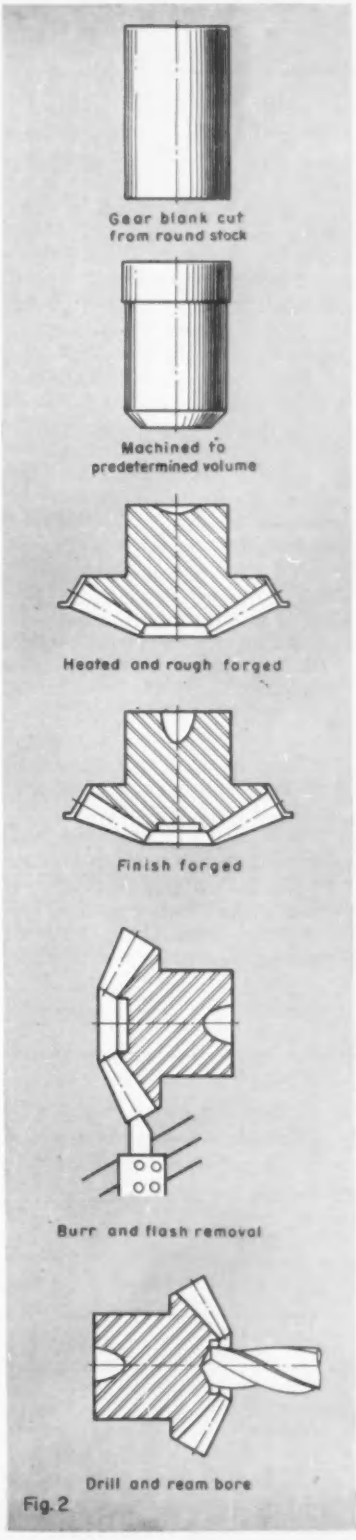

Gear blank cut from round stock
Machined to predetermined volume
Heated and rough forged
Finish forged
Burr and flash removal
Drill and ream bore

Fig. 2

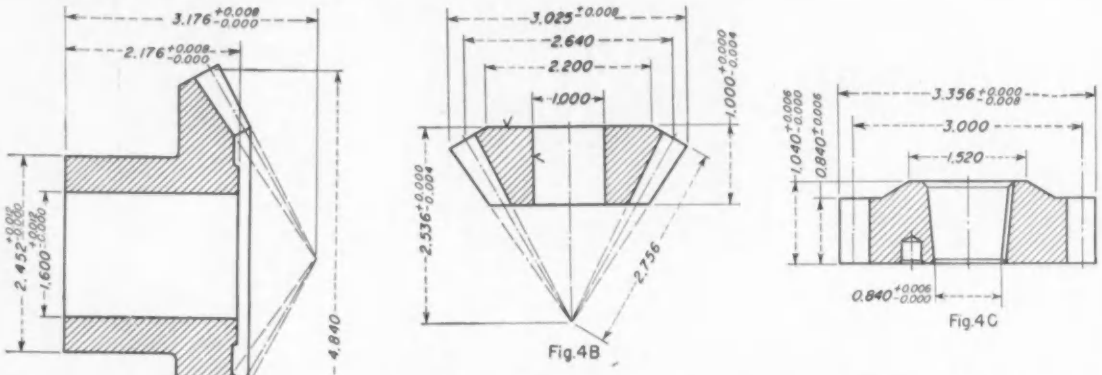


Fig. 4—Dimensions and tolerances of three precision-forged gears used in applications where operating speeds are less than 1200 rpm. Machining of teeth after forging not required; machining of other surfaces indicated by finish marks. Bevel gears in (A) and (B) are used in an automobile differential; spur gear in (C), in which only the tapered bore is machined, is used for the test results shown in Fig. 5.

however, the accuracy of the teeth can be held to within ±0.002 in. (±0.05 mm) which is acceptable for gears running at speeds up to 1200 rpm or 1800 fpm surface speed. The gears in Fig. 4 fall under this classification. In (A) and (B), the front inner face and the teeth are forged to such good accuracy that no machining is required. Machining is performed on the bore, hub and backing face, the gears being centered in a special chuck to obtain accurate concentricity.

Two spur gears of the type shown in Fig. 4(C) were inspected for tooth accuracy after forging. Inspection was performed on a Mehr gear tester using a spherical insert. Each tooth was individually tested and tolerance variations were recorded on a chart as shown in Fig. 5. Required tooth thickness, not shown in Fig. 4(C), is 0.926 ± 0.002 in. Total tolerance range, therefore, is 0.004 in. Teeth of the master gear were made to almost exactly 0.926 in. thickness. As can be noted, the upper tolerance limit is exceeded by 0.0004 in. by two teeth in gear A. All teeth in gear *B* are within the tolerance range.

To group the distribution closer toward the middle of the tolerance range, it would be necessary to reduce tooth thickness of the master gear by 0.0008 in. This would bring all teeth within the tolerance range, but would require a new die—an impractical solution. However, by continued inspection of the die forgings an empirical relationship can be developed between the dimensions of the master gear and the dimensions of the forged product for future die constructions.

Cost Comparison

Precision-forged gears are not always cheaper to produce than machined gears. The forging process is to be preferred if the cost of machining the teeth is high in proportion to the total cost. For example, savings in the production of bevel gears similar to Figs. 4(A) and (B) were about 11 per cent and for spur gears similar to Fig. 4(C) about 32 per cent. One important factor in cost savings is the state

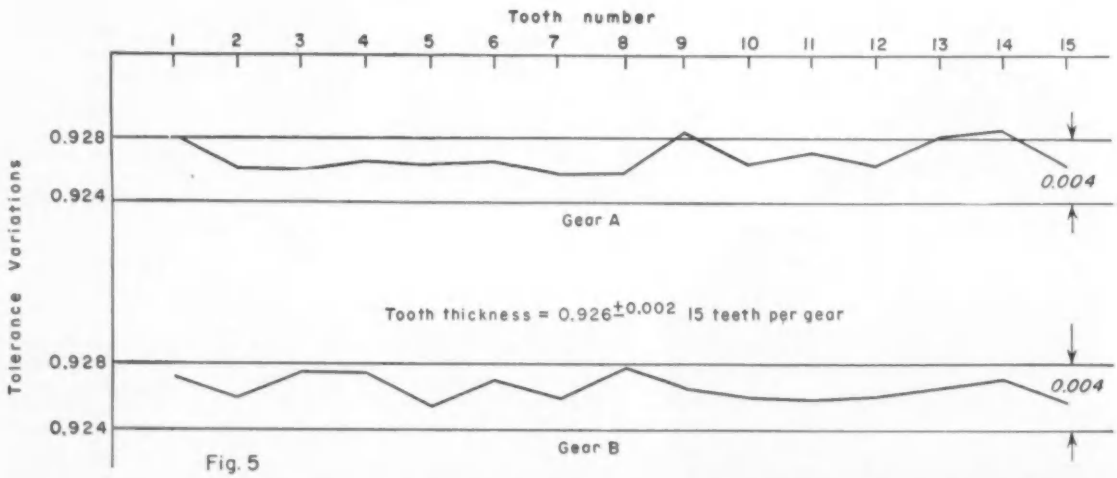


Fig. 5—Variations in tooth accuracy of two gears, with dimensions as per Fig. 4(C). Upper tolerance limit is exceeded by 0.0004 in. by two teeth of gear *A*. Gear *B* is within tolerance range.

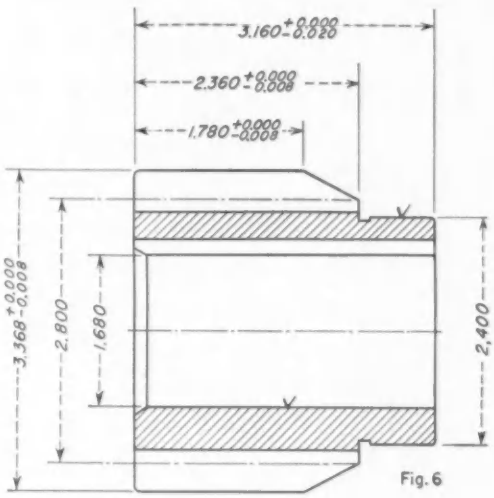


Fig. 6

Fig. 6—Example of a gear that is cheaper to machine than to precision-forge. Savings in tooth forming is small in comparison to the high cost of the blank.

of the gear after forging. It must require as little machining as possible and one machining cut should be sufficient. Another factor is the complexity of the gear contour. Gears with notches, pads and stops are invariably cheaper to produce by the forging process.

The spur gear in Fig. 6, on the other hand, is more expensive. Savings on tooth forming are small in comparison to the higher cost for the machined blank and the need for additional grinding to meet a requirement of noiseless operation.

Economy of the process is also influenced by the total number of gears to be made. Generally, it is not economical to produce less than 500 pieces, taking into consideration the tooling cost, set-up time, machining cost, depreciation of equipment, and overhead.

Spiral Gears

Spiral gears pose more difficulties than spur or bevel gears. Their specifications usually require close tolerances for high speed and noiseless applications. Forging the teeth with an extra allowance for machining and then finishing the teeth on a gear cutting machine afforded no economical advantage. A more satisfactory method was developed by lapping the teeth after forging. Fig. 7(A) shows results of tests of tooth accuracy of 10 spiral gears without lapping; Fig. 7(B) the results of a second batch of gears whose teeth were lapped—a pronounced improvement.

EDITOR'S NOTE: How strength requirements, weight, cost and press capacity effect the design of large forgings is discussed in "Problems in the Design of Large Forgings," *Product Engineering*, 1954 Annual Handbook page D12. Included are tables showing the effect of size on minimum mechanical properties of aluminum forgings, cost relationship for several forging designs, and relationship between upsetting pressure and thickness.

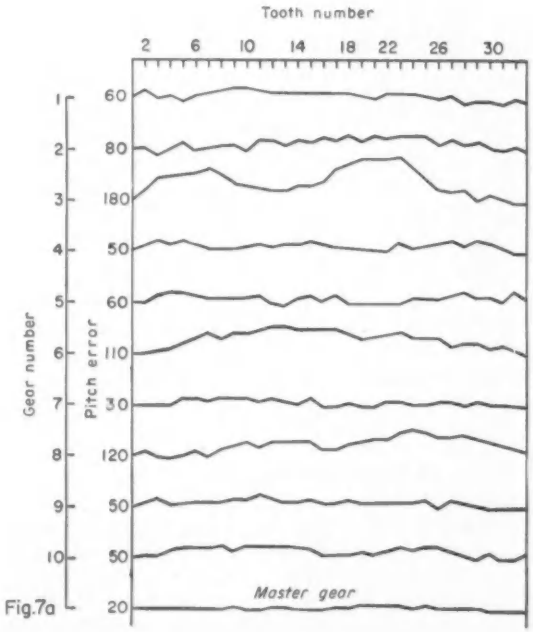


Fig.7a

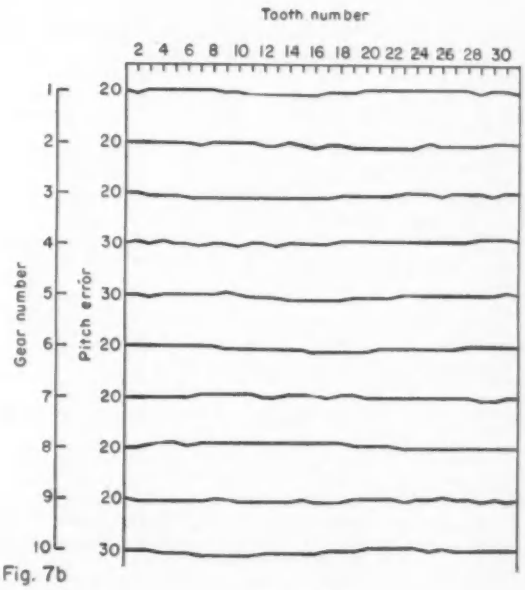


Fig. 7b

Fig. 7—Variations in tooth accuracy of spiral gears. Inspection was performed on ten gears, each gear having 32 teeth. **(A)** Tolerance variations after forging. Bottom row shows results of tests on the master gear. **(B)** Tolerance variations after forging and lapping.

Surface Curvature

ERNEST WILDHABER
Rochester, N. Y.

A useful method for defining and generating warped surfaces, such as embodied in helical gears, worm threads and hypoid gears; review of physical significance of curvature and derivation of concepts and equations; two sample applications of the method.

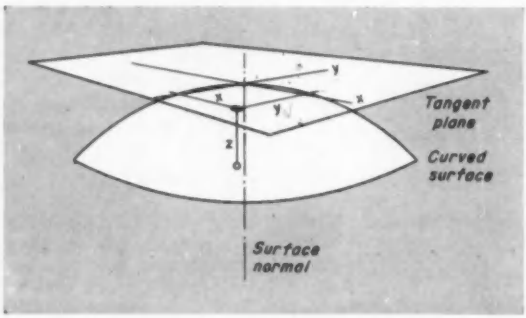


Fig. 1—Perspective view of curved surface, tangent plane and coordinate axes set up in tangent plane.

TERMS AND SYMBOLS

C_1, C_2, C_3	— Parameters of the equation of a curved surface
Curvature	— Inverse radius ($1/R$)
e	— Distance in the tangent plane between chosen point and line of contact of a cylindrical element with tangent plane
Element	— One of two cylindrical surfaces which are the resolved components of a given curved surface
i	— Inclination of surface normal to normal of tangent plane
i_r, i_p	— Radial and peripheral components of i.
Principal directions	— Directions of two elements of a curved surface which are perpendicular to each other
P	— Any point on a curved surface
P_T	— The projection of point P on the tangent plane
R, R_1, R_2	— Cylindrical element radii
Surface Normal	— Perpendicular to a surface at a chosen point
Tangent Plane	— Plane to which the surface and its component elements are tangent
x, y	— Coordinates in tangent plane starting from point of intersection of the two tangent lines
z	— Elevation of curved surface above or below tangent plane
$\varkappa$	— Angle of chosen element relative to X axis in the tangent plane
$\varkappa_0$	— Angle between X axis and principal direction of a curved surface
Σ	— Included angle between a pair of component elements

Description and generation of curved surfaces for the teeth of helical gears, worm threads, spiral bevel and hypoid gears and other warped surfaces pose a difficult problem which is considerably simplified by the use of the geometrical concept of surface curvature. The method described herein has been successfully applied to the production of spiral bevel and hypoid gears for many years, and more recently, to other types of gears as well as warped surfaces of high precision.

The Three Dimensional Problem—First step in the analysis of a warped surface is to pick a mean point within the region to be studied. It is assumed that this region is continuous and free from mathematical singularities and boundary restrictions. A plane is imagined tangent to the surface at the mean point. This plane is known as the tangent plane. A line through the mean point and perpendicular to the tangent plane establishes the normal to the surface at that point. This construction is shown in Fig. 1.

A coordinate system may be set up in the tangent plane, so that the rectangular coordinate axes intersect at the selected mean point, the contact point with the surface. Points of any surface may be located by the x and y coordinates of their projections to the tangent plane, and by the distance z of their points from the tangent plane, that is, their elevation.

Elevation z can be expressed as a function of the coordinates x and y. As the surface is tangent to the plane of the coordinate axes, this function can have no first order terms in x or y.

$$z = C_1 x^2 + C_2 xy + C_3 y^2 \qquad (1)$$

In the immediate vicinity of the origin of the coordinate system the coordinates are very small, and the cubic and higher order terms are so much smaller than the quadratic terms that they may be neglected. In mathematical language, infinitesimal coordinates are considered for the surfaces, so that the higher order terms are infinitesimal of a higher order and are negligible. The first assumption is, therefore, that only small areas of the curved surface are considered which may be described with sufficient accuracy by Eq (1) above.

Surface Elements—Major advantage of the use of surface curvature as a mathematical tool lies in substituting for the given surface an approximate or simplified surface that can be compounded from more elementary surfaces like cylinders or cones.

SUMMARY OF PROPOSITIONS

Any curved surface can (over small areas) be resolved into a pair of cylindrical surfaces, hereafter called elements, which contact a tangent plane of the surface along two straight lines. These intersect at the point of tangency with the surface.

Radii and directions of the two elements are related and mathematically defined.

Elevation of any point in the curved surface above or below the tangent plane is the algebraic sum of the elevations of the corresponding points of the cylindrical elements.

Lines perpendicular to a surface (whether cylindrical or of more complex form) are called surface normals. A unit length may be added to the extension of a surface normal beyond its intersection with the surface. The projection of this unit length on the tangent plane has length proportional to the inclination of the normal and direction. The projections of two surface normals of cylinders on the tangent plane may be geometrically added to give the inclination and direction of the resultant curved surface at any point. The system of normals of each cylindrical element all have the same projected direction and their inclination is directly proportional to the distance of the considered projected point from the line of contact of the cylindrical element surface with the tangent plane. The elevation of any point of a cylindrical element from the tangent plane is proportional to the square of this distance.

A curved surface can be resolved into an infinite number of pairs of component elements having different included angles and radii. There is always one such pair of elements at right angles to each other. Their directions are called the principal directions of the curved surfaces.

The sum of curvatures $(1/R_1 + 1/R_2)$ is constant for all pairs of the same curved surface.

When viewed in the direction of one of its component elements, a curved surface has a profile or contour-curvature equal to the curvature of that element. The line of contact between the curved surface and its component element extends in the direction of the second element of the pair.

This approximate surface must be producible by ordinary cutters and grinding wheels, which are themselves simple cylinders or cones, it must have the same tangent plane at the mean point as the actual surface, and its curvature must match that of the actual surface.

Simplest method is to compound this approximate surface from cylinders. Fig. 2 shows part of a cylinder. It is shown in contact with a tangent plane which contains the axes of the coordinate system. This plane appears here as a straight line. The cylindrical surface appears as an arc with curvature radius R_1. Point P on the cylinder has an elevation z' from the tangent plane. The surface normal PP' at P is inclined at an angle i to the normal at O and passes through the center of curvature.

When a unit distance is plotted from P to P' on the normal, its projection $P_TP'_T$ on the tangent plane is a measure of its inclination. OX is the line of contact of the cylindrical surface with its tangent plane. The lines parallel thereto are lines of constant elevation from the tangent plane. Point P, with coordinates x, y has a normal PP' whose projection $P_TP'_T$ appears perpendicular to the line of contact OX, as will all the normals of a cylindrical surface. The projected distance $P_TP'_T$ is directly proportional to the ordinate y, and inversely proportional to the curvature radius R_1.

A Pair of Component Elements—The same cylindrical surface, with curvature radius R_1, is indicated in Fig. 3 by its line of contact OX with the tangent plane. And the same point P with its projected normal $P_TP'_T$ is shown there. Shown also is another cylindrical surface, which contacts the tangent plane along a line OX' and which has a curvature radius R_2. Point P_T has a distance e from OX'. Neglecting terms of higher order, the point P_T of the second cylindrical surface has an elevation z'' from the tangent plane

$$z'' = \frac{e^2}{2\,R_2} \tag{2}$$

while point P_T of the first one has an elevation

$$z' = \frac{y^2}{2\,R_1} \tag{3}$$

The two elementary cylindrical surfaces are now combined so that their elevations z' and z'' add up to a resultant elevation

$$z = z' + z'' \tag{4}$$

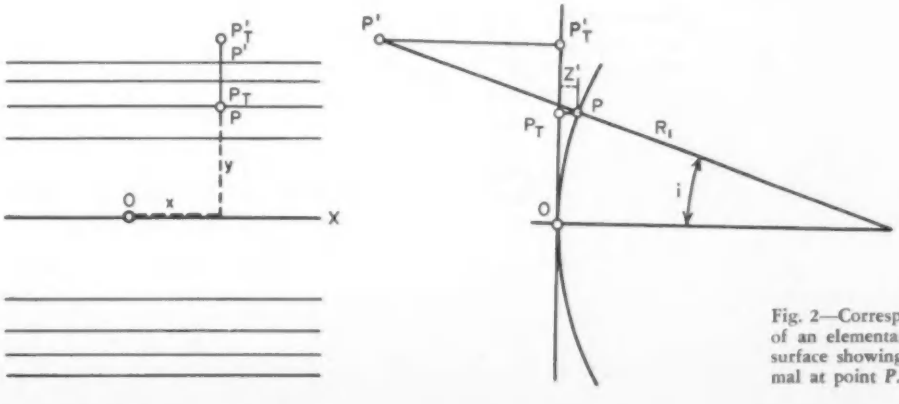


Fig. 2—Corresponding views of an elementary cylindrical surface showing surface normal at point *P*.

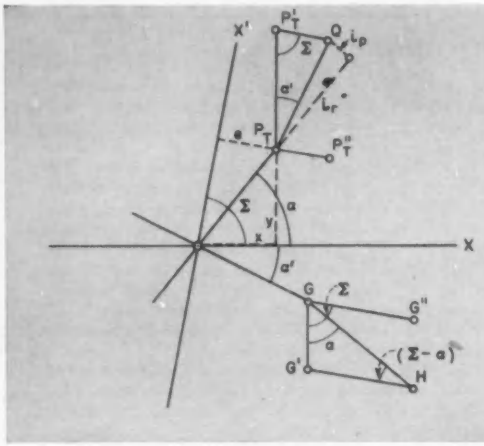


Fig. 3—A pair of cylindrical elements contacting the drawing plane along *OX* and *OX'* build up a curved surface. The inclination of its normal at *P* is obtained by geometrical addition.

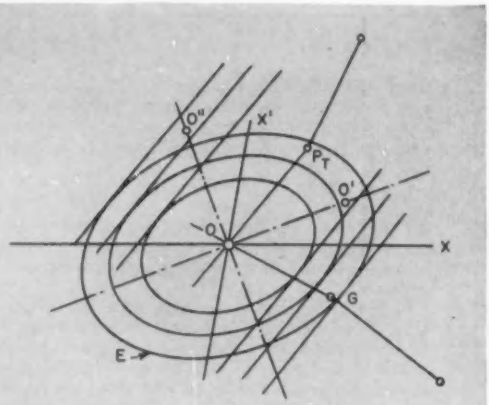


Fig. 4—An entirely convex surface built up of two elementary cylindrical surfaces *OX*, *OX'* whose axes are on the same side of the tangent plane.

The simplified Eq (1) of a curved surface contains three constants C_1, C_2, C_3. Any such surface can be obtained by the combination of two cylindrical surfaces, for after assuming the direction of one cylindrical surface, there are still three characteristics to be chosen; the angle Σ included between them, and the radii of curvature R_1 and R_2.

As the direction of one cylindrical surface may be assumed at will, there are an infinite number of pairs of cylindrical surfaces suited to define a given surface.

Derivatives dz/dx and dz/dy can likewise be obtained as the aggregates of the derivatives dz'/dx, dz''/dx, and dz'/dy, dz''/dy respectively. Derivatives may also be formed in directions other than x and y.

$P_TP'_T$ in Fig. 3 expresses the inclination of the normal at *P* of the first cylindrical surface and $P_TP''_T$ expresses the inclination of the normal of the second cylindrical surface at the same x, y, location. Their resultant P_TQ is obtained by drawing P'_TQ equal to $P_TP''_T$ and parallel thereto.

Since the angles are very small P_TQ can be considered the sine of the resultant inclination angle, its tangent or its arc measure. It is the inclination of the newly derived combination of cylinders OX and OX'.

A second pair of elementary cylindrical surfaces may be used to build up the same curved surface as defined by the pair OX and OX'. One cylindrical surface of this second pair is assumed to contact the tangent plane along line OP_T. The direction of the other element of the pair may be determined as follows. The surface normal at P_T is known. P_TQ is its projection. As point P_T lies on the line of contact of the new element OP_T with the tangent plane, this element has no influence on the inclination of the normal P_TQ. The inclination of the normal is determined entirely by the other element of the pair. Its line of contact OG with the tangent plane is bound to be perpendicular to the projected normal P_TQ. And the curvature radius of element OG must be just so large that it produces an inclination P_TQ of the surface normal at P_T. That is, the normal distance of point P_T from line OG, divided by the curvature radius of the second element should be the sine or the arc or the tangent of the inclination angle. This requirement determines the curvature radius of OG.

To determine the curvature radius of element OP_T, consider a point G on the line of contact OG, and determine the surface normal of the original surface at G in the same way as was done at P_T. The inclination of this surface normal is determined solely by element OP_T, and the projected normal appears perpendicular thereto. Its inclination at G, multiplied by the sought curvature radius equals the normal distance of point G from line OP_T.

Convex and Concave Surfaces—The two elements of a pair of elementary cylindrical surfaces may be both convex or both concave, or one may be convex and the other concave. In the equations which follow, their curvature radii should be introduced with opposite algebraic signs in the latter case. The principles of the procedure apply regardless of sign.

Fig. 4 indicates a curvature surface defined by elements OX, OX' of equal sign, so that the axes are both located on the same side of the tangent plane. The surface is viewed in the direction of its normal at O. Lines E of constant elevation from the tangent plane are shown, forming a topographical map of the surface. The lines E shown have a progressively increasing elevation and are ellipses. Shown also are the straight lines of a cylindrical surface which contacts the tangent plane along line OP_T and has line contact with the curvature surface. These lines have the same progressive elevations as ellipses E. Fig. 4 illustrates the same surface described in Fig. 3.

Fig. 5 is a similar map of a curvature surface where the axes of the elementary cylindrical surfaces are on opposite sides of the tangent plane. Curves of constant elevation are hyperbolas *H*. The surface intersects the tangent plane in two straight lines passing through O. These are the asymptotes of the hyperbolas.

Principal Directions–Projection P_TQ of a unit distance plotted on the normal at P (Fig. 3) can be resolved into a radial component i_r and a peripheral component i_p.

$$i_r = 0P_T\left[\frac{\sin^2\alpha}{R_1} + \frac{\sin^2(\Sigma-\alpha)}{R_2}\right] \tag{5}$$

$$i_p = \tfrac{1}{2}\,0P_T\left[\frac{\sin 2\alpha}{R_1} - \frac{\sin 2(\Sigma-\alpha)}{R_2}\right] \tag{6}$$

Component i_p becomes zero when

$$\frac{\sin 2\alpha}{R_1} = \frac{\sin 2(\Sigma-\alpha)}{R_2} \tag{7}$$

The particular direction α which fulfills this equation shall be called α_o. Transformation yields

$$\operatorname{ctn} 2\alpha_0 - \operatorname{ctn} 2\Sigma = \frac{R_2}{R_1 \sin 2\Sigma} \tag{8}$$

The cotangent repeats every 180 deg and ctn 2α repeats every 90 deg. There are, therefore, two directions at right angles to each other which fulfill this equation,

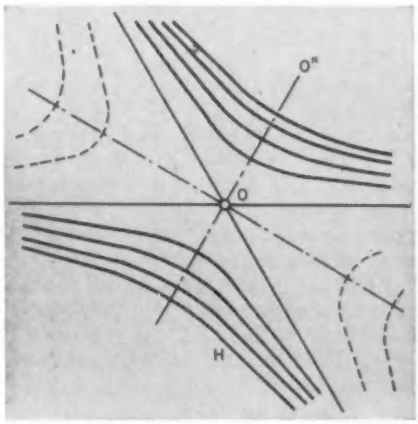


Fig. 5—A partly convex and partly concave curvature surface.

making the peripheral component, i_p, zero. In these directions the normal at P intersects the surface normal erected at the origin O and the normals projected in the tangent plane are radial lines. They are called the principal directions. Principal directions OO' and OO'' are indicated in Fig. 4.

Having determined the principal directions of α_o, and $(\alpha_o + 90)$ for Eq (8) for a given pair of elements OX and OX' the curvature radii of the principal elements R_{10} and R_{20} may be determined. Substitution of α_o for α in Eq (5) permits determination of i_r, the radial component of the inclination at point O' which is at a radial distance OO'_T from the mean point. At O' the inclination i_r is equal to OO'_T/R_{20} and from this relationship R_{20} can readily be determined. Substitution of $\alpha_o + 90$ for α in Eq (5) permits determination of i_r at O'' and R_{10}.

Mathematical transformation simplifies this logical derivation into the explicit relations

$$\frac{1}{R_{20}} = \frac{\sin^2\alpha_0}{R_1} + \frac{\sin^2(\Sigma-\alpha_0)}{R_2} \tag{9}$$

$$\frac{1}{R_{10}} = \frac{\cos^2\alpha_0}{R_1} + \frac{\cos^2(\Sigma-\alpha_0)}{R_2} \tag{10}$$

The sum of Eq (9) and (10) results in the very simple relationship

$$\frac{1}{R_{10}} + \frac{1}{R_{20}} = \frac{1}{R_1} + \frac{1}{R_2} \tag{11}$$

The sum of the curvature of any pair of elements defining a given surface is constant, and equal to the sum of the curvature of the elements extending in the principal directions.

Direction of Contact–Line of contact OG (Fig. 3) is perpendicular to the projected normal P_TQ. Angle $\alpha' = P'P_TQ$ is equal to the angle XOG.

$$(\operatorname{ctn}\alpha' + \operatorname{ctn}\Sigma) = \frac{\sin\alpha}{\sin(\Sigma-\alpha)\sin\Sigma} \cdot \frac{R_2}{R_1} \tag{12}$$

When based on the principal direction, where Σ is a right angle, it assumes the simpler form

$$\operatorname{ctn}\alpha' = \tan\alpha \cdot \frac{R_{20}}{R_{10}} \tag{13}$$

Curvature of a Tangent Cylinder–When it is necessary to determine the radius R_x of curvature of an element at an angle α with an element R_{10} of principal direction, the following formula will serve.

$$R_x = R_{20}\sin^2\alpha + R_{10}\cos^2\alpha \tag{14}$$

Equidistant, or Parallel, Surfaces–In gear problems it is often preferable to work with an imaginary surface equidistant from the tooth surface. It may pass through a pitch point in the center of a gear tooth-space. It has the same system of normals as the actual tooth surface and the solution obtained for the equidistant surface can be directly translated into the solution for the tooth surface.

Conical Surfaces–Like the cylindrical surface, the conical surface has a straight profile with no curvature in one of the two principal directions. The amount of curvature in the second or peripheral direction is equal to the curvature of a normal section laid in the direction of the periphery, that is perpendicular to the surface. Its radius is equal to the normal radius OC in Fig. 6. P is a point displaced from O in peripheral direction by an infinitesimal amount. Its normal PC continues to pass through C. C is therefore the curvature center of this normal section,

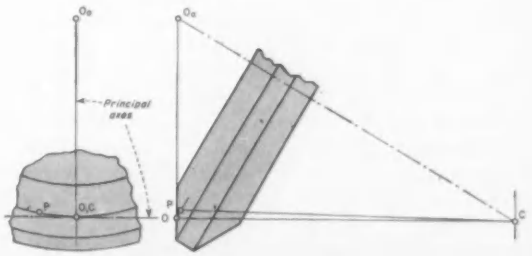


Fig. 6—For curvature, a conical surface is equivalent to a cylindrical surface with radius OC.

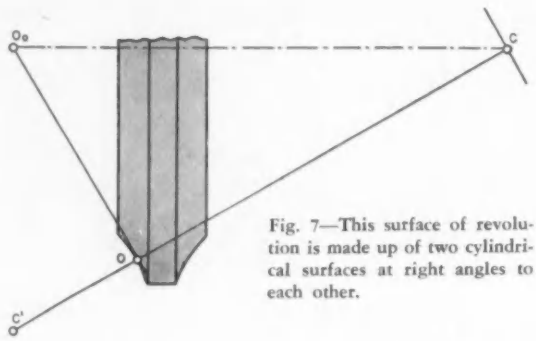


Fig. 7—This surface of revolution is made up of two cylindrical surfaces at right angles to each other.

and OC is the radius of curvature. The cylindrical element to substitute for the given conical surface has a radius OC equal to the normal radius of the conical surface.

Surfaces of Revolution—Fig. 7 shows a surface of revolution whose axis O_sC lies in the drawing plane. The surface of revolution shown can be resolved into two cylindrical surface elements extending in the tangent plane at right angles to each other. One element is convex and the other is concave. The convex element extends along the profile tangent OO_s and has a curvature radius OC. The concave element extends in peripheral direction, perpendicular to the drawing plane of Fig. 7. Its curvature radius is equal to the curvature radius OC′ of the axial profile.

APPLICATIONS

The Involute Helicoid—This is probably the simplest form of helicoid. Fig. 8 includes a view along the axis of an involute helicoid, and a corresponding front view.

The involute helicoid is made up of straight lines, which are tangent to its base helix. All points on any one of its straight lines have a common tangent plane. Thus, the points of straight line OO′ have a tangent plane perpendicular to the drawing plane of Fig. 8, (lower view). The helicoid intersects planes perpendicular to its axis in involutes, of which I is one.

Points of line OO′ have the same curvature as a conical surface with axis CO′ parallel to the axis of the helicoid. This axis lies on the base cylinder B of the involute helicoid.

OC is the radius of curvature of the involute helicoid in a section perpendicular to OO′. Dash-and-dot line *h* is the helix passing through the considered mean point O. The helix tangent at O makes an angle η with the straight line OO′ of the involute helicoid, which appears enlarged in the axial view of Fig. 8.

Consider a normal section at O, that is a plane section perpendicular to the helix tangent at that point. It is shown in Fig. 9. Point O is in the center of a tooth space. The profile of the considered imaginary helicoid passes through O and appears in dotted lines *i*. Its curvature center is at C′, on normal OC′. Plane T is parallel to the axis of the helicoid and tangent to the helix at O. The normals (OC′) of opposite sides of the tooth space are inclined at the normal pressure angle ϕ_n to this plane.

With R denoting the radius of the helicoid to O, the gear radius, and ψ the helix angle at O, distance OC′ can be expressed as

$$OC' = R\,\frac{\sin\phi_n}{\cos^2\psi}$$

and the angle η as

$$\tan\eta = \sin\phi_n \tan\psi$$

These properties of the involute helicoid are known, and have been discussed by Dr. Werner F. Vogel and Douglas Hughson, in *Industrial Mathematics*, Vol. 3, 1952.

The immediate object is to determine the profile curvature of a grinding wheel which can produce the involute helicoid. The axis CC_w of the grinding wheel lies in the normal plane, the drawing plane of Fig. 9. It has a normal radius OC equal to $R_c/\sin\phi_n$, wherein R_c is the cutter or wheel radius OC_w. C″ is the center of profile curvature of the grinding wheel, as yet unknown.

Fig. 10 shows the tangent plane at O to the imaginary helicoid. The straight line generator OO′ of the involute helicoid is inclined at the above angle η to the direction OX of the helix tangent. The curvature radius R_i (= OC in Fig. 8) is known. The quantity $R_i/\cos^2\eta$ is the radius of curvature OC′ of the normal profile, which extends in the direction OO_s.

The surface of the grinding wheel or cutter can be resolved into a pair of cylindrical elements extending in directions OX and OO_s respectively. The curvature radius of the latter is equal to OC (Fig. 9) and to $R_c/\sin\phi_n$. The curvature radius $R_p = OC''$ of the element extending in direction OX is as yet unknown.

OX and OO_s are at right angles, so that the use of Eq (14) is in order. Angle η takes the place of angle α. Of the two elements OX and OO_s one is positive and the other is negative, as their curvatures are opposite. With the present notations the equation reads

$$R_i = R_p\cos^2\eta - \frac{R_c}{\sin\phi_n}\sin^2\eta;\ \text{hence}$$

$$R_p = \frac{R_i}{\cos^2\eta} + \frac{R_c}{\sin\phi_n}\tan^2\eta;\ \tan\eta = \sin\phi_n\tan\psi$$

$$R_p = R\,\frac{\sin\phi_n}{\cos^2\psi} + R_c\sin\phi_n\tan^2\psi$$

The first member of the right side of this equation is the distance OC′ in Fig. 9. The second member is distance C′C″, which increases with the size of the grinding wheel.

Thus far calculations were made for the imaginary tooth profile which passes through point O. The actual tooth profile passes through point P. And so does the wheel profile.

C″ remains the curvature center of the wheel profile which passes through P, because this profile lies in a principal direction. Its curvature radius is

$$PC'' = OC'' - OP$$

The wheel profile may be made an involute with curvature center C″ in the case of zero profile ease-off. Its base circle B has its center at C_i and is tangent to OC at C″.

Neither the wheel profile, nor the normal section of the involute helicoid is an involute exactly. But they are curves of similar character. If OC″ is large, the wheel profile may even be made a circular arc.

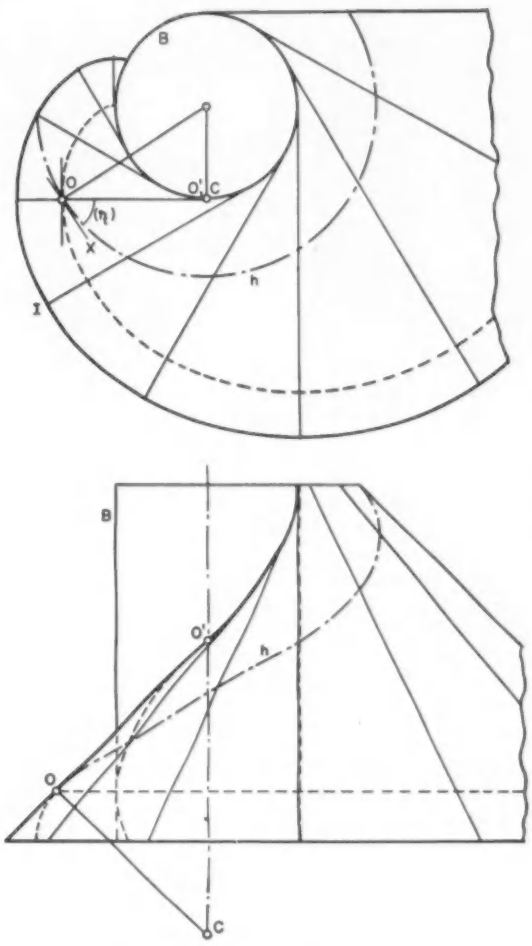


Fig. 8—Views of an involute helicoid.

Examples

No. 1 What is the distance OC' of the center of tooth profile curvature C' from O of a gear with $R = 2$; $\phi_n = 20$ deg.; $\psi = 45$ deg?

Answer $R \dfrac{\sin \phi_n}{\cos^2 \psi} = 1.368$

No. 2 How large is distance OC' when the helix angle $\psi = 30$ deg instead of 45 deg in the above example?

Answer 0.912

No. 3 What is the distance of the curvature center C'' (Fig. 9) of the wheel profile from the curvature center C' of the normal profile of the above gear, at a wheel radius $R_e = OC_w = 10$ in.? What is it at a wheel radius $R_e = 6$ in.?

Answer: It is equal to $R_e \sin \phi_n \tan^2 \psi$

$$\left.\begin{aligned} C'C'' &= 3.420 \text{ at } \psi = 45 \text{ deg} \\ &= 1.140 \text{ at } \psi = 30 \text{ deg} \end{aligned}\right\} R_e = 10$$

$$\left.\begin{aligned} C'C'' &= 2.052 \text{ at } \psi = 45 \text{ deg} \\ &= 0.684 \text{ at } \psi = 30 \text{ deg} \end{aligned}\right\} R_e = 6$$

No. 4 What is the distance OC'' of the curvature center C'' from mean point O in the above examples?

Answer: $OC'' = OC' + C'C''$

$$\left.\begin{aligned} OC'' &= 4.788 \text{ at } \psi = 45 \text{ deg} \\ &= 2.052 \text{ at } \psi = 30 \text{ deg} \end{aligned}\right\} R_e = 10$$

$$\left.\begin{aligned} OC'' &= 3.420 \text{ at } \psi = 45 \text{ deg} \\ &= 1.596 \text{ at } \psi = 30 \text{ deg} \end{aligned}\right\} R_e = 6$$

No. 5 What is the curvature radius PC'' of the wheel profile in the above examples, when distance OP is 0.200?

Answer: $PC'' = OC'' - OP$
$= OC'' - 0.200$

No. 6 How much is the curvature radius PC'' of the wheel profile reduced, when the wheel radius R_e is reduced by $\frac{1}{2}$ in.?

Answer: $\frac{1}{2} \sin \phi_n \tan^2 \psi$; $\sin \phi_n = 0.3420$
0.171 at $\psi = 45$ deg; 0.057 at $\psi = 30$ deg

No. 7 How large is the curvature radius PC''_b of the wheel profile after this reduction in wheel radius, in the above examples?

Answer: $PC''_b = PC'' - \frac{1}{2} \sin \phi_n \tan^2 \psi$

$$\left.\begin{aligned} PC''_b &= 4.417 \text{ at } \psi = 45 \text{ deg} \\ &= 1.795 \text{ at } \psi = 30 \text{ deg} \end{aligned}\right\} R_e = 9.500$$

$$\left.\begin{aligned} PC''_b &= 3.049 \text{ at } \psi = 45 \text{ deg} \\ &= 1.339 \text{ at } \psi = 30 \text{ deg} \end{aligned}\right\} R_e = 5.500$$

No. 8 How much separation is there between the wheel profiles with curvature radii PC'' and PC''_b, at a point Q corresponding to the top end of the tooth profiles, when $PQ = \frac{1}{4}$?

Answer: Because the two wheel profiles are curves similar in character, their separation Δz at point Q is produced principally by the difference in curvature. It is approximately

$$\Delta z = \tfrac{1}{2} PQ^2 \left(\frac{1}{PC''_b} - \frac{1}{PC''} \right) = \tfrac{1}{2} PQ^2 \frac{PC'' - PC''_b}{PC'' \cdot PC''_b}$$

$$\left.\begin{aligned} \Delta z &= 0.00026 \text{ at } \psi = 45 \text{ deg} \\ &= 0.00054 \text{ at } \psi = 30 \text{ deg} \end{aligned}\right\} R_e = 10 \text{ to } 9.5$$

$$\left.\begin{aligned} \Delta z &= 0.00054 \text{ at } \psi = 45 \text{ deg} \\ &= 0.00095 \text{ at } \psi = 30 \text{ deg} \end{aligned}\right\} R_e = 6 \text{ to } 5.5$$

A grinding wheel dressed to a constant axial profile would produce a variation of about Δz at the profile ends, as its radius is gradually decreased by $\frac{1}{2}$ in. These amounts are

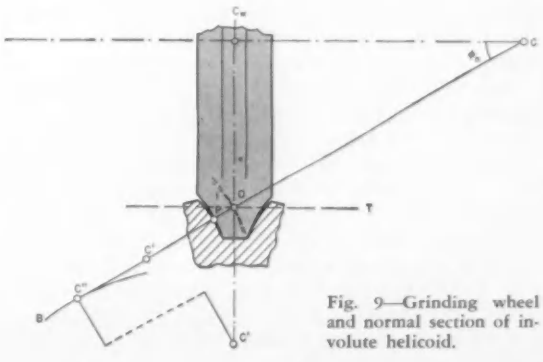


Fig. 9—Grinding wheel and normal section of involute helicoid.

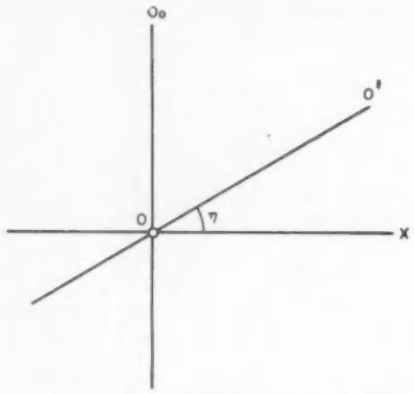


Fig. 10—Tangent plane at O of involute helicoid.

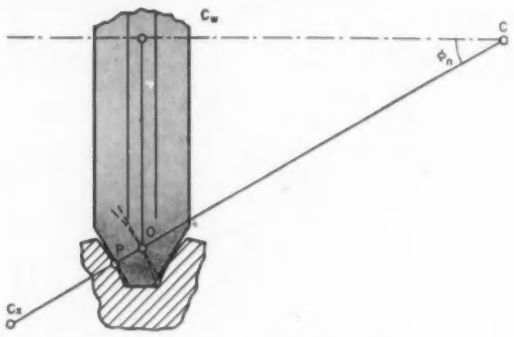


Fig. 11—Conical grinding wheel and normal section of helical thread produced therewith.

between 2½ and 9½ tenths of a thousandth of an inch. This is considered high and the axial wheel profile should be changed more frequently.

Non-Involute Helicoids—Consider a point O of the mean helix, as was done on the involute helicoid. The mean helix, and the normals at all points of the mean helix, are exactly as they are on a coaxial involute helicoid which has the same tangent plant at O. The general helicoid differs from the involute helicoid by rising above or falling below the involute helicoid on both sides of the mean helix.

Fig. 10 shows the common tangent plane at O. The involute helicoid contacts this plane along line OO', which is inclined at the angle η from the direction OX of the helix. The surface normals at points of line OX can be determined solely from the cylindrical element OO' which represents the involute helicoid. The general helicoid is obtained by adding to this surface element another surface element, that extends in the direction OX of the helix.

The curvature surface at O of the general helicoid can be defined by a pair of elements which make the above angle η with each other. Element OO' is the element with curvature radius R_t, which represents the involute helicoid. Element OX has a curvature radius R_h in a section perpendicular thereto, which characterizes the departure from the involute helicoid.

General helicoids may also be defined with a given grinding wheel or milling cutter. The problem then is to determine the curvature radius R_h of element OX, and to find the center of curvature of the normal section for the helicoid which passes through O.

This problem is solved by comparing the given grinding wheel with a grinding wheel of the same radius R_c, which has a radius of profile curvature OC'' adapted to produce the involute helicoid. The curvature $1/R_h$ is the difference in profile curvature of the latter wheel and the given wheel. It is $1/OC''$ minus the curvature of the given wheel.

As stated above, starting with the involute helicoid, add or subtract a cylindrical element OX to the wheel to obtain the specified shape on the wheel, and subtract or add the same cylindrical element OX to the helicoid. The resultant surface remains a helicoid because this element is applied in the direction of the helix at O. Element OX has a curvature radius R_h.

The profile curvature in a normal section, $1/OC_z$ in Fig. 11, is the profile curvature of the involute helicoid minus the curvature of element OX:

$$\frac{1}{OC_z} = \frac{1}{OC'} - \frac{1}{R_h}$$

This equation also determines $1/R_h$ when OC_z is given. To determine a grinding wheel or cutter for a given helicoid, subtract $1/R_h$ from the profile curvature $1/OC''$ of the wheel of equal radius OC_w, which can produce a corresponding involute helicoid.

Examples

No. 1 A helical worm has a radius of $R = 1\frac{1}{2}$ to point O, a normal pressure angle $\phi_n = 20$ deg and a helix angle of $\psi = 60$ deg, that is a lead angle of 30 deg, at that radius. Consider an imaginary thread surface which passes through point O. If that surface were an involute helicoid, where would the center of curvature C' of its normal section be? What does distance OC' in Fig. 9 amount to?

Answer: $OC' = R \dfrac{\sin \phi_n}{\cos^2 \psi} = 2.052$

No. 2 If the thread surface were involute helicoid in the above example, at what distance OC'' from O would the center of curvature C'' of the concave wheel profile be, when the wheel radius $R_c = OC_w = 10$ in.?

Answer: $OC'' = OC' + C'C'' = 2.052 + R_c \sin \phi_n \tan^2 \psi$
$= 2.052 + 10.261 = 12.313$

No. 3 If the thread surface passing through O and defined in (1) is produced with a straight-sided grinding wheel of $R_c = OC_w = 10$, what is the radius of curvature R_h of the element extending along the helix?

Answer: $R_h = OC'' = 12.313$

Use of a straight grinding profile is shown in Fig. 11, which is a normal section like Fig. 9. Here also the drawing plane contains the wheel axis CC_w.

No. 4 Where is the center of curvature C_z of the normal section of the thread surface produced with a straight-

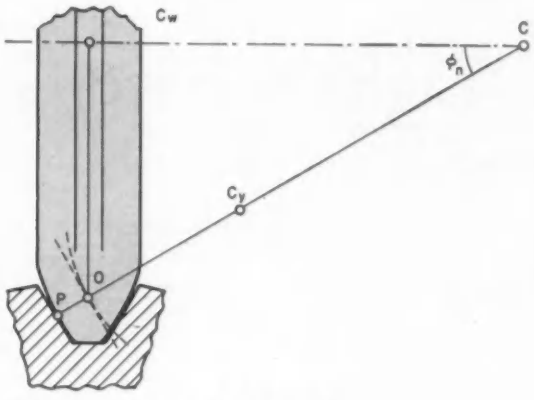


Fig. 12—A straight thread profile requires a convex profile on the grinding wheel.

sided wheel and defined in (3)? What is distance OC_z in Fig. 11?

Answer: $$\frac{1}{OC_z} = \frac{1}{OC'} - \frac{1}{R_h} = \frac{1}{2.052} - \frac{1}{12.313}$$

$$OC_z = 2.463$$

The above equation may be transformed:

$$OC_z = \frac{R_h \cdot OC'}{R_h - OC'} \; ; R_h - OC' = C'C'' = R_c \sin \phi_n \tan^2 \psi$$

$$OC_z = OC' \frac{(C'C'' + OC')}{C'C''} = OC' \left(1 + \frac{OC'}{C'C''}\right)$$

$$OC_z = R \frac{\sin \phi_n}{\cos^2 \psi} \left(1 + \frac{R}{R_c \sin^2 \psi}\right)$$

No. 5 The actual thread surface is equidistant to the above surface and passes through a point P at a distance OP from O. It is further defined by the helix angle $\psi = 60$ deg at O, by the normal pressure angle $\phi_n = 20$ deg at O, and by the radius R to point O. It is produced with a straight-sided grinding wheel of a radius $R_c = OC_w = 10$ in.

If this surface were to be cut with an end-mill with radial axis OC_w (Fig. 11), where would the center of curvature of the cutting profile be?

Answer: At C_z; because at point O an end-mill corresponds to $R_c = O$.

No. 6 Does the center of curvature C_z also coincide with the center of curvature of the normal thread-profile which passes through point P?

Answer: Nearly so, but not exactly.

No. 7 The above thread, which is ground with a straight-sided wheel of 10 in. mean radius, $OC_w = 10$, ordinarily will be cut first. It may be cut with a milling cutter of $1\frac{1}{2}$ in. mean radius, $OC_w = 1\frac{1}{2}$. At what distance R'_p from O should the curvature center of its concave cutting profile be, to produce the same thread surface as the grinding wheel?

Answer: An involute helicoid would require a radius of curvature OC'' of the wheel profile passing through O:

$$OC'' = 2.052 + 1.500 \sin \phi_n \tan^2 \psi = 3.591$$

$$\frac{1}{R_p'} = \frac{1}{OC''} - \frac{1}{R_h} \; ; R_p' = \frac{R_h (OC'')}{R_h - OC''} = 5.070$$

No. 8 What is the radius of curvature at P of the actual cutter profile in the above example, when OP equals 0.200?

Answer: $5.070 - 0.200 = 4.870$

Fig. 12 shows a thread of straight profile in its normal section at O. In this case a convex profile with curvature center C_y is required on the grinding wheel. At O the relative curvature between the imaginary thread profile and wheel profile is the same as in other forms of threads. Thus OC_y is equal to OC_z of Fig. 11 when the data are otherwise the same.

NOTE: This article is condensed from a paper presented before the Industrial Mathematics Society, Detroit, Mich.

Russians Catching Up in Electronics

"WITHIN THE NEXT THREE YEARS Russian ability and knowledge of the electronics field will be abreast of that in the U.S. Up to now they have been copying most of your products, but at the same time they have been advancing their own knowledge at a rapid pace." This was the comment of an eminent West German engineer and instrument manufacturer. The source of his information is his own engineering staff, at least ten of whom are East German engineers who defected to the West.

These engineers state that "the Russians manage to learn of the latest technical developments in the U.S. companies and research laboratories long before anyone else. They must have one of their kind in almost every big plant in the country in order to do this."

The German manufacturer, who wishes to remain anonymous, says that the Russians have set up several special academies whose sole purpose is to thoroughly investigate the latest U.S. engineering development, and pass this knowledge on to the large corps of designers responsible for Russian product development. He said that the Russians have good engineers but that a poor quality product is caused by a lack of high quality machinery. He added that he has been approached by a Russian representative who wanted to buy instruments and some communications equipment—enough to keep his plant busy for the next two years.

With no military Air Force, much of West Germany's electronics production, like communications and aircraft navigation equipment, is for export. The radio industry in Germany is producing a high quality product. He compared the medium receiver there to a good high-fidelity receiver in this country.

Bead Chains for Light Service

BERNARD WASKO, Chief Engineer, Voland and Sons, Inc.

FIG. 1—*Misaligned sprockets.* Nonparallel planes usually occur when alignment is too expensive to maintain. Bead chain can operate at angles up to, $\theta = 20$ deg without slipping off sprocket.

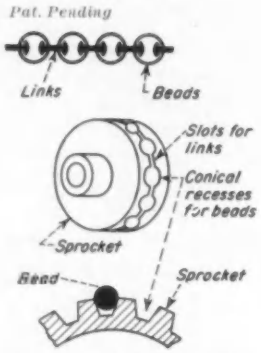


FIG. 2—*Details of bead chain and sprocket.* Slots in sprocket allows beads to sit firmly in conical recesses.

FIG. 3—*Skewed shafts* normally require two sets of spiral gears to bridge space between shafts. Angle misalignment does not interfere with bead chain operation.

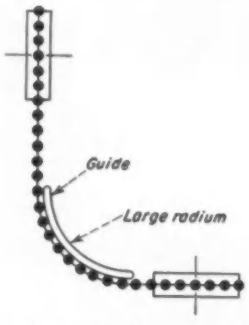
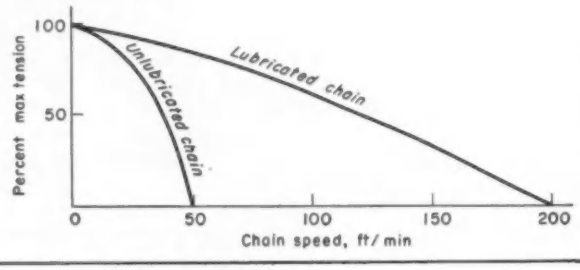


FIG. 4—*Right angle drive* does not require idler sprockets to go around corner. Suitable only for very low torque application because of friction drag against guide.

Table I - Load capacity of bead chains - capacity varies with bead diameter, chain speed and lubrication

Bead dia (in.)	Beads per ft	Max working tension (lb)
3/32	102 - 103	20
1/8	72 - 73	35
3/16	50 - 51	70
1/4	36 - 37	150



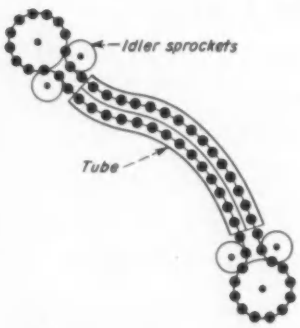


FIG. 5—*Remote control* through rigid or flexible tube has almost no backlash and can keep input and output shafts synchronized.

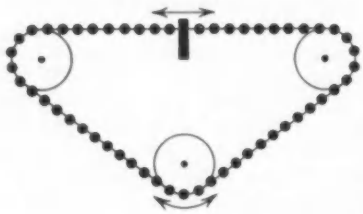


FIG. 6—*Linear output from rotary input.* Beads prevent slippage and maintain accurate ratio between input and output.

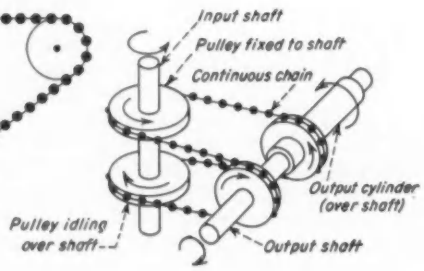


FIG. 7—*Counter-rotating shafts.* Input shaft drives two counter-rotating outputs (shaft and cylinder) through a continuous chain.

Where torque requirements and operating speeds are low, bead chains offer a quick and economical way to: Couple misaligned shafts; convert from one type of motion to another; counter-rotate shafts; obtain high ratio drives and overload protection; control switches and mechanical counters.

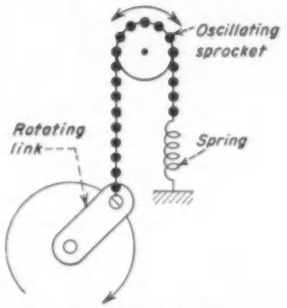


FIG. 8—*Angular oscillations from rotary input.* Link makes complete revolutions causing sprocket to oscillate. Tension on chain maintained by spring.

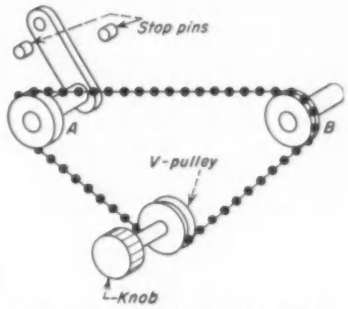


FIG. 9—*Restricted angular motion.* Pulley, rotated by knob, slips when limit stop is reached; shafts A and B remain stationary and synchronous.

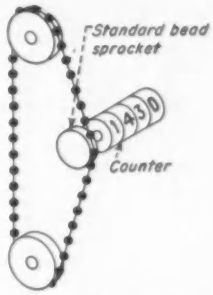


FIG. 10—*Remote control of counter.* For applications where counter cannot be coupled directly to shaft.

FIG. 11—*High-ratio drive* less expensive than gear trains.

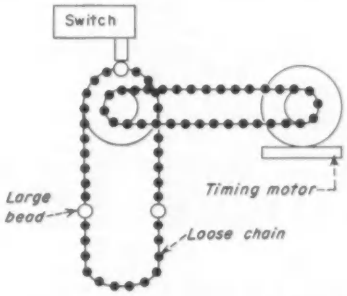


FIG. 12—*Timing chain* containing large beads at desired intervals operates microswitch. Chain can be lengthened to contain thousands of intervals for complex timing operations.

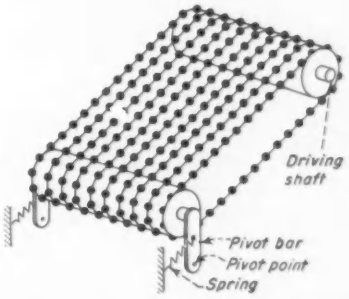


FIG. 13—*Conveyor belt* composed of multiple chains and sprockets. Tension maintained by pivot bar and spring. Width of belt easily changed when desired.

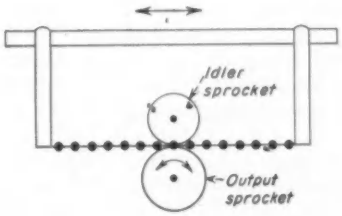


FIG. 14—*Gear and rack* duplicated by chain and two sprockets. Converts linear motion into rotary.

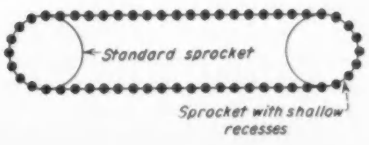


FIG. 15—*Overload protection.* Shallow sprocket gives positive drive for low loads; slips one bead at a time when overloaded.

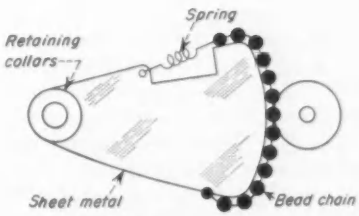
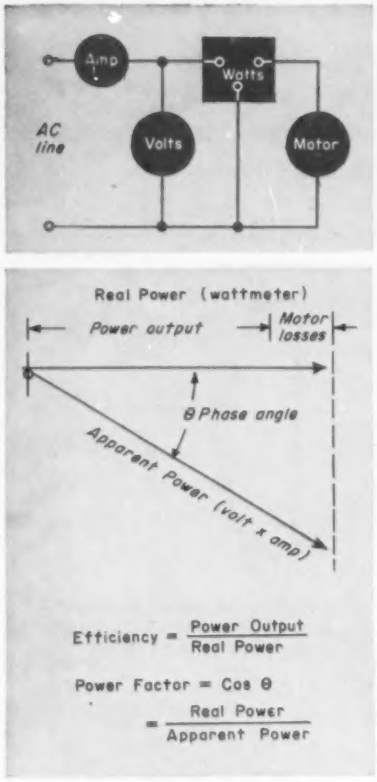


FIG. 16—*Gear segment* inexpensively made with bead chain and spring wrapped around edge of sheet metal. Collars keep sheet metal from twisting on shaft.



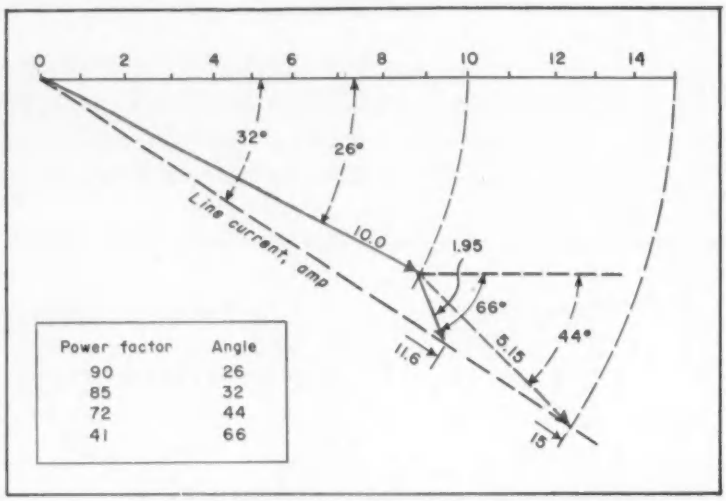


Fig. 2—For the example used in the text a compressor motor drawing 10 amp at 90 per cent power factor combined with a fan motor of 1.95 amp at 41 per cent power factor will give an over-all current of 11.6 amp at 85 per cent power factor. For the limiting conditions of 15 amp and 85 per cent power factor (dashed line) the fan motor could draw 5.15 amp at 72 per cent power factor.

Fig. 1—To determine over-all power factor and line current for equipment having two or more motors, the power factor of each motor can be expressed graphically and then added vectorially.

MOTORS . . .

Selecting fan motors for equipment that requires maximum power for minimum current; influence of power factor, efficiency, speed and starting torque on cost and performance; charts for selecting permanent-split capacitor motors.

R. F. FRICKE
Motor Design Engineer
Westinghouse Electric Corp., Lima, Ohio

DIRECT CONNECTED auxiliary fan or blower motors used with single-phase space or cooling equipment such as air conditioning units, are generally either shaded-pole or permanent-split capacitor type. Because of inherent advantages of higher power factor and better efficiency, capacitor-type motors are generally used on applications over 1/12 hp. But to obtain optimum ratio of performance to cost when applying capacitor-type motors, four major factors must be evaluated: motor power factor, efficiency, operating speed, and starting torque.

Power Factor

For any a-c machine or component with a magnetic circuit, the actual power taken from the supply line is the product of instantaneous values of current and voltage. Presence of a magnetic circuit normally causes the peak current in each cycle to lag behind the peak in voltage, and the power available as indicated by a wattmeter is less than the product of separate current and voltage readings. The ratio of real power (wattmeter reading) divided by apparent power (product of current and voltage reading) is the power factor, Fig. 1. Power factor depends on the design of the magnetic circuit and winding; a motor with a low power factor design will draw more line current for the same power output and efficiency than a motor with a higher power factor.

Where an application requires maximum horsepower for minimum line current, or for a specified current rating, power factor must be carefully evaluated. This is particularly important when applying auxiliary motors such as fan or blower motors drawing current from the same line terminals as a main drive or compressor motor.

The magnitude of motor current as well as the power factor affects the power factor of the equipment in which it is used. Permanent-split capacitor motors have advantages over shaded-pole motors in both these aspects. Typical current value for a 1/12-hp permanent-split capacitor motor is 1.4 amperes at 90 per cent power factor.

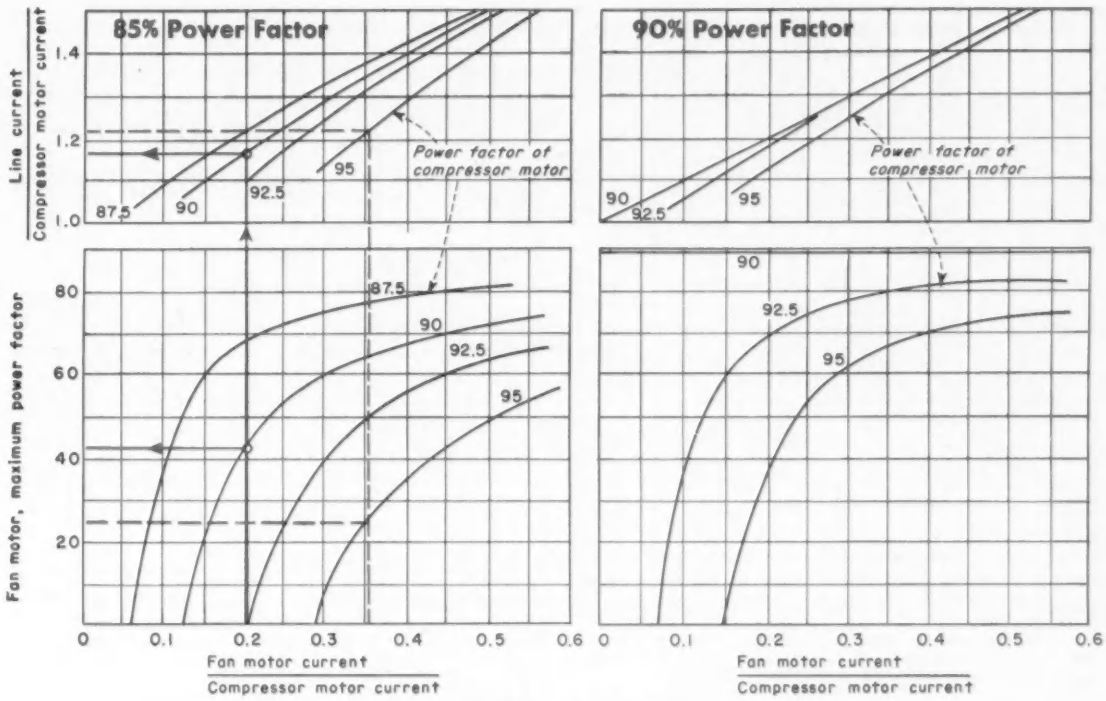


Fig. 3—Graphical data for selecting minimum power factor and miximum current of a direct-connected fan motor for a given compressor motor. Chart at left for equipment designed for a minimum power factor of 85 per cent; at right for 90 per cent power factor specification.

for Direct-Connected Fans

It is neither necessary nor economical to require a fan motor drawing 2 amp produce the same power factor as one drawing 4 amp. For example, a typical fan-motor application specifies a minimum power factor of 85 per cent for the over-all equipment, in which the compressor motor draws 10 amp at a power factor of 90 per cent. Assume the fan motor initially selected draws 1.95 amp with 42 per cent power factor. Total line current can be obtained graphically by simple vector analysis as indicated in Fig. 2. For this example the total line current is 11.6 amp at the 85 per cent power factor specified at the minimum.

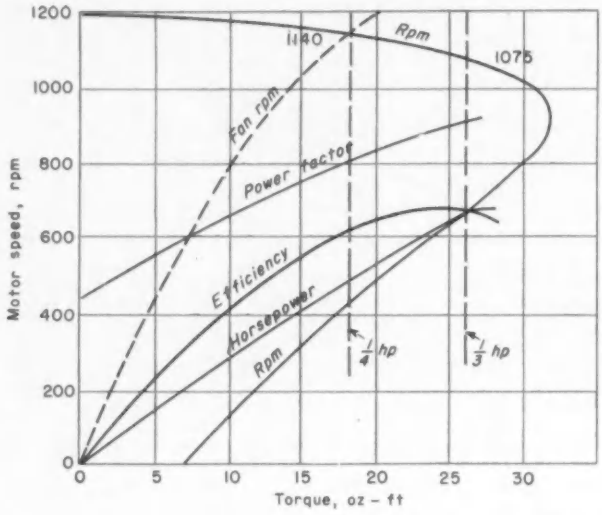
If the fan motor has a power factor less than 41.5 per cent, the equipment power factor will fall below the 85 per cent minimum, unless the motor current is reduced. Current drawn by relays and other auxiliary equipment is omitted here; usually the value is relatively small, but its effect should always be weighed.

In addition to a limiting value of power factor, the equipment specification usually sets a maximum value for the total line current. If a value of 15 amp is used for the above example, the fan motor may draw a current of 5.15 amp at 72 per cent power factor and still meet the over-all requirements, as shown in Fig. 2 by the dashed line.

Similar computations for maximum and minimum fan motor current and power factor limits are the basis for the design charts in Fig. 3 for an overall power factor of 85 per cent (left) and 90 per cent (right). Note that line current and fan motor current are expressed in terms of compressor motor current. The lower curves in each chart determine the minimum allowable fan motor power factor, while the upper curves show line current resulting from the use of a given fan motor.

For the example used above (85 per cent over-all power factor, and 10 amp compressor motor current at 90 per cent power factor), a fan motor current of 1.95 amp is 19.5 per cent of compressor current. From this value on the abscissa a vertical line (shown in color) intersects the 90 per cent power factor curve at 42 per cent fan motor power factor. Total line current is read from the upper curve by projecting the 19.5 per cent line to the 90 per cent curve for the compressor motor power factor, where the ordinate is 116 per cent of compressor motor current, or 11.6 amp.

In the second example (dashed line in color) the com-



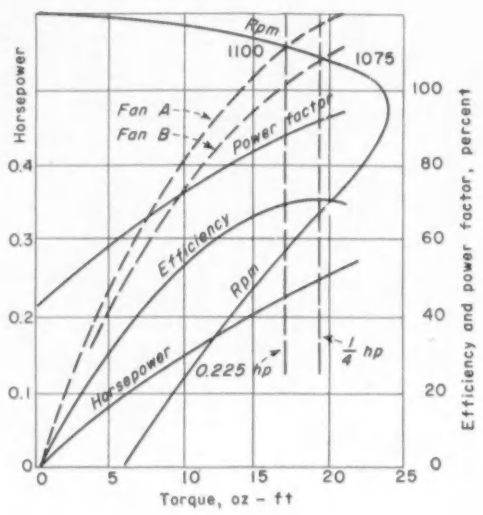


Fig. 4 Above—Fan speed should be matched to rated motor speed which is lower for permanent split capacitor motors than for split phase motors. Left, at 1140 rpm (rated speed for a split-phase motor) a 1/3 hp permanent split capacitor motor develops only 1/4 hp. Right, dropping down in rating to a 1/4 hp size with the same fan the motor develops only 0.225 hp at 1100 rpm; changing fan to give an operating speed of 1075 rpm results in maximum performance with minimum losses.

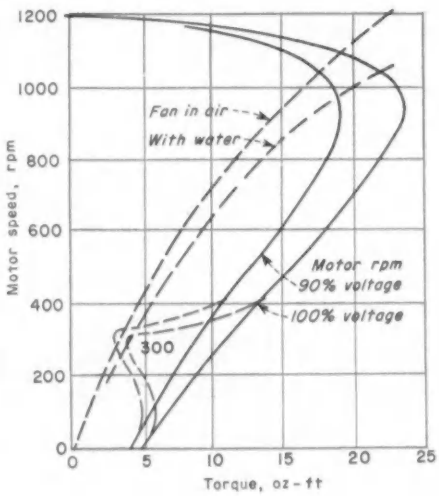


Fig. 5 Right—Starting and accelerating torques required by fan in air and with water at 100 per cent and 90 per cent line voltage. Torque irregularities common with shaded-pole motors (dashed lines in color) may cause motor to "hang up" in starting.

Table II—Comparison of Fan Motor Performance

(For example shown in Fig. 4)

Motor Rating, hp	Fan	Speed, rpm	Output, hp	Efficiency, per cent	Power Factor, per cent	Current, amp	Motor Loss BTU
1/3	A	1140	0.250	62	81	1.62	392
1/4	A	1100	0.225	68	87	1.23	273
1/4	B	1075	0.250	69	91	1.30	286

pressor motor power factor is 95 per cent of compressor current. The fan motor power factor may be as low as 25 per cent and yet maintain the over-all minimum of 85 per cent power factor. Line current will be 122 per cent of compressor current or 12.2 amp. Curves for compressor power factors below 85 per cent are not shown since application of such motors is uneconomical design practice. Designs requiring a minimum over-all power factor of 90 per cent impose such severe limitations that the choice of fan motor usually is limited.

Efficiency

The product of power factor and efficiency is the useful output in watts per volt-ampere. Since applied line voltage may be considered constant, this product is proportional to watts output per ampere. With constant voltage and efficiency, a high power factor can result in low line current. But some minimum value of current is needed for magnetization.

Motor power factor can be further increased by lowering efficiency. This method of increasing power factor, although frequently used, is in direct conflict with economic design. This method is equivalent to connecting resistors across the line terminals of the equipment. In air conditioning equipment these additional losses must eventually be dissipated through the condenser.

Operating Speed

Speed plays an important part in the over-all performance of permanent-split capacitor motors used for fan duty. Although four-pole motors are the standard of the fractional hp motor industry, air noise is generally too high for use with direct-connected fans. As a result, the more special six and sometimes eight-pole designs are used. NEMA rates this type of motor at 1075 rpm for 6 poles, 60 cps, as compared with 1140 rpm for split phase and capacitor-start motors. To improve inherently low starting torque, permanent-split capacitor motors use a relatively high resistance rotor, which tends to reduce motor operating speed. The optimum combination of efficiency

and power factor is a function of the speed at which breakdown torque occurs.

The tendency to overpower fans to obtain high speeds and maximum air delivery is not good practice. As a typical example, split-phase motors conventionally used on heating equipment are rated at 1140 rpm. Performance curves for a permanent split capacitor motor delivering ¼ hp at 1140 rpm are shown at left in Fig. 4. At the NEMA standard speed of 1075 rpm this motor is actually rated ⅓ hp. Using a fan with the load characteristics shown, this motor operates with 62 per cent efficiency at a power factor of 81 per cent.

If the same fan is driven by a ¼ hp (1075 rpm) permanent split capacitor motor, the motor delivers 0.225 hp at 1100 rpm at a power factor of 87 per cent and 68 per cent efficiency, as shown at right in Fig. 4. (Fan efficiency is assumed constant over the speed range involved.) If 11.1 per cent reduction in hp is not acceptable, the fan may be redesigned to have the speed-torque characteristic shown at B in Fig. 4, bringing the motor performance up to ¼ hp.

Compared with the ⅓ hp motor first considered (left in Fig. 4), this combination of a ¼ hp motor and modified fan will carry rated load with only 73 per cent of the losses. Also, for the same ventilation system, the ¼ hp motor will probably operate at a lower temperature. Table I summarizes the performance data for this example. Note that efficiency and power factor are highest for the ¼ hp motor operated at its rated speed of 1075 rpm. Motor losses are only 4 per cent higher for 11 per cent increase in power output with a decrease of only 25 rpm in operating speed.

Both the ¼ and ⅓ hp motors have 1200 rpm synchronous speed and similar speed-torque characteristics. Breakdown occurs at about 950 rpm. Increasing loads have little effect on losses down to 1000 rpm, although the losses in the ¼ hp motor are lower because of the lower rating.

Lower operating speed of the ¼ hp drive results in less noise. Since more effective use is made of motor materials, the lower operating speed provides the more economical design. On an equivalent basis the ⅓ hp motor theoretically requires 133 per cent of the active materials —iron and copper—required by the ¼ hp design. However, these two motors probably use identical shafts, ventilating fans, end shields, punchings, labor, and assembly methods. As a result the amount of active material used, as well as the manufacturing costs of these motors, may vary from the theoretical ratio.

Starting and Accelerating

Another factor in applying permanent-split capacitor motors is ability of the motor to start and accelerate its load. Starting torque of permanent-split capacity and shaded pole motors is inherently low. This can be increased in the capacitor motor, but with reduction in performance and increase in motor cost. Low starting torque for fan motors provides smooth, quiet starts. Where fan or blower blades are isolated from the hub with resilient mountings, low starting acceleration is important to keep from damaging these mountings.

Low voltage and static friction are two important variables that must be considered for positive starts under expected operating conditions. For example, a motor on full voltage has an average locked-rotor torque of 5 oz-ft with no radial load on the motor bearings. Starting torque varies from 4 to 6 oz-ft depending on the angular position of the rotor. This is called "cogging" and is caused by the change in reluctance as rotor teeth pass stator teeth. Cogging can be minimized by increased rotor skew and larger air gaps, but usually at the expense of full-load performance.

Torque developed by motors varies closely with the square of applied voltage. If this is a 115 volt motor, it would be expected to operate at ±10 per cent of rated voltage or as low as 103.5 volts. An additional safety factor is usually applied in the form of reduced voltage starting. If the motor must start on 90 volts minimum starting torque developed by the motor at 90 volts is $4 \times [90/115]^2$ or 2.5 oz-ft.

A 5-lb fan fastened to the motor shaft will increase static friction of the motor bearing. With new bearings, static friction varies with rotor position because of high spots. This friction can safely vary a maximum of 1 oz-ft because the motor always develops at least 250 per cent of the required load starting torque. If a low cogging point is coincident with a bearing high spot, at which frictional torque is greater than 2.5 oz-ft, the motor will not start.

For all cases the safety factor applied is in the reduced voltage and no additional torque factor need be used. Although the actual difference between torque developed and torque required is small, the percentage difference is usually large. But measurement of these low starting-torque values by usual methods of dynamometer, string and pulley, or brake arm, is inadequate in failing to evaluate the effects of static friction. The most satisfactory solution is to measure starting ability at reduced voltage.

Acceleration of direct-connected fans and blowers is a function of the difference in torque developed by the motor and that required by the fan throughout the speed range. Cogging can be neglected as soon as the motor reaches a few rpm, and the speed-torque characteristic usually follows a smooth curve, as shown in Fig. 5. Normally, permanent-split capacitor motors have the characteristics indicated by the solid lines, and little difficulty is encountered in accelerating the fan to normal running speed.

The dashed lines in the torque curves are caused by harmonic cusps often found in shaded-pole motors, and are the result of the primary winding distribution. Unlike cogging, which may vary from motor to motor in a given design, harmonic cusps are generally established by the design itself. In such a design, the fan will be slowly accelerated to full-load speed. Under low-voltage conditions or for an increase in starting load such as the fan dipping in a trough of evaporator condensate, the fan and motor torque curves will intersect at about 300 rpm and the motor will fail to accelerate beyond this speed.

Editor's Note: See also the reference sheet in this issue on page 215, "Selecting Motors for Fans and Centrifugal Pumps," for a nomogram relating motor torque, power and speed for applications where torque varies with the square or speed and power increases with the cube of speed.

RESINS *for Reinforced Plastics*

ERNEST SCHLIEBEN
Manager, Missiles Department
Sylvania Electric Products, Inc.

Five major classes of resins evaluated for processing characteristics, mechanical and electrical properties, appearance, cost, advantages and limitations.

SUCCESSFUL DESIGN AND MANUFACTURE of reinforced plastic products is greatly dependent upon the type of synthetic resin used in the process. There are now over two hundred resins commercially available for use in reinforced plastics. The list is continually expanding to provide resins tailored to produce specific desirable characteristics for products such as: Machine and pump housings, structural parts for aircraft, roofing materials, textile bobbins, panel boards, fishing poles, truck and automobile bodies, instrument cases, furniture.

The field of reinforced plastics is still new and dynamic; standards for comparison purposes have yet to be developed. The problem stems from a multiplicity of resins and reinforcements (fillers) resulting in many compositions—each developed for specific applications. However, the resins can be classified into five major groups and analyzed as to their properties, processing characteristics, cost, advantages and limitations.

Processing of a reinforced plastic product begins with the impregnation of a mass of fibers (usually glass in the form of a mat) by a syrupy liquid (the resin). The resin, depending on type, is as thin as pure glycerine or as thick as heavy syrup. The glass-fiber mat is roughly formed into the general shape of the product and then wetted with a small quantity of the syrup and dried. Glass mat already impregnated with resin is also available.

Rough pre-forms of impregnated mat—formed to the general shape of the product—are then placed in a contouring mold; more syrup is added, and the formed laminate is cured in a matter of minutes. Curing takes little heat and pressure. In practice, some products are cured without heat or pressure by adding a catalyst to the syrup.

Products are tailored for heat resistance, hardness, electrical properties, flexibility and strength by using certain resins, by changing the thickness of the mats, or by varying the type of mat or amount of glass fibers. There is also a latitude in cost. Pure resins that give translucent products are higher in cost than resins for opaque products. Where transmission of light is not important, as in machine parts, lower cost resins can be used.

Functions of the Resin

Prime function of the resin is to act as a binder. Structurally, it plays a secondary role to the reinforcement material. The resin holds the reinforcement in position and interconnects it so that loads can be transferred from one fiber to another (if fibers are not directly connected).

Second function is to stabilize the reinforcement material. A single unsupported glass fiber under compression will collapse under a very small load; but, surrounded by a resin, the fiber is stabilized so that it can take a compression load up to the point where the glass in the fiber (or rod) fails.

For structural parts, the reinforcement is more important than the resin. The resin being considerably more elastic in compression than an equal area of glass, takes only about one to two per cent of the load. Further, if loaded to its ultimate compressive strength, the resin will fail before the glass in the fiber.

A similar situation in tension prevails—glass fiber is stable in tension, so derives no support from the resin. The fiber is also stiffer and stronger than an equal area of resin under tension, and therefore takes almost all of the tension load.

For example, mat reinforcement does not create as strong a part as cloth reinforcement, which in turn is not as strong as roving reinforcement, providing the roving is in the direction of maximum load. If the final position of the fibers in the molded part is not straight, the fibers will not be able to take as high compressive and tensile loads. Best kind of reinforcement is roving which is made from straight parallel fibers—even glass cloth results in a crimped fiber which reduces the strength of the reinforcement.

Strength of the reinforced plastic part is influenced by the degree to which the resin completely surrounds glass fiber. Insufficient wetting by the resin leaves portions of the glass fibers unsupported and reduces the strength under compressive loads. Since glass fibers are hard to wet by most resins, chemical or flame pre-treatment is necessary to improve wetting characteristics and hence the strength of molded parts.

The resin may be the determining factor, however, for electrical parts. Arc resistance, volume resistivity, loss tangent, and dielectric strength vary considerably among resins, but relatively little among glass reinforcements. Appearance of the finished product also is influenced by the resin. Other factors that vary with type of resin used

Table I—Comparison of Resins (Glass Cloth or Mat Reinforcement)

	Polyesters	Polyesters with trially cyanurate (heat resistant)	Low pressure phenolics (heat resistant)	Silicones	Epoxys
Cost (dollars per lb)	0.35–0.40	0.40 (approx.)	0.25–0.40	over 1.00	0.90–1.00
Tensile strength at room temp., psi	40,000–50,000	40,000–50,000	35,000–40,000	25,000–30,000	45,000–55,000
Maximum temp., * F	300	400–500	450	400–500	250
Shelf life	Good	Good	Poor	Good	Good
Solvent required	None	None	Yes	None	None
Ease of preparing part for molding	Easy	Easy	Moderately Difficult	Difficult	Moderately Difficult
Machinability	Fair	Fair	Fair	Fair	Fair
Cure pressure, psi	10–150	10–150	10–1,000	10–150	10–1,000
Cure temperature, F	200–300	200–300	300	300	300
Ease of molding	Easy	Easy	Moderately Difficult	Difficult	Difficult
Appearance	Good to Excellent	Good to Excellent	Good	Good	Excellent
Electrical Performance: D-C A-C	Good Excellent	Good Excellent	Fair Fair	Excellent Good	Fair Fair
Chemical resistance	Good	Good	Good	Excellent	Excellent
Translucent	Yes	Yes	No	No	No

* Maximum continuous temperature at which molded parts can be used. Tensile strength at this temperature usually less than half that of room temperature.

are: Index of refraction, transmission of different wave lengths of light, surface texture, and thickness uniformity (ability of the resin to remain in place without flowing or without migrating from the surface of the molded part during the curing stage).

The Ideal Resin

The resin acts principally to bind and stabilize the reinforcement fibers and determines the characteristics of the molded product. With this in mind, the ideal resin should be:

(1)—Low in cost.

(2)—Able to meet the performance requirements.

(3)—Non-toxic liquid capable of being stored indefinitely under all conditions.

(4)—Easily applied by pouring on the reinforcement, spraying, or immersing the fibers in the resin.

(5)—Able to thoroughly wet the fibers without run-off regardless of whether the fibers are laid flat or on the vertical sides of a mold.

It should then be possible to:

(1)—Handle the impregnated fibers by hand without experiencing tack.

(2)—Rapidly mold the part with minimum pressure or heat and in shortest time.

(3)—Remove the part from the mold without sticking.

(4)—Obtain a uniformly finished surface that is an exact replica of the mold surface.

(5)—Obtain a product that is hard, tough, and strong and does not deform with age.

In practice, ideal resins do not exist. Cheap materials cannot be found in nature that can be used in liquid form to impregnate various kinds of reinforcement materials and then be converted to hard infusible solids through the addition of low heat, pressure, or some other simple process. Binders which have been found satisfactory for impregnants for the reinforcements are synthetic resins called polyesters, phenolics, epoxides and silicones. With the exception of silicone, practically all resins are long chain polymers or monomers of hydrocarbons. That is, they are complex large-molecule structures containing carbon, oxygen, hydrogen, and nitrogen atoms arranged in various ways.

Synthesis of resins involves a series of chemical processes which, in turn, involves many types of equipment. The final product is the result of a complex manufacturing process, and cost varies from 25 cents to over a dollar a pound.

Manufacturing Requirements

The resin manufacturer is interested in seeing that the molder uses the resin exactly as specified to develop its maximum properties. If it has been stored too long, he would prefer to have it discarded. If, for proper development of its physical properties, a molding temperature of 225 F and a cure time of 30 minutes with a post cure

of 3 hours is required, he wants this schedule followed exactly, even though the molder may want to depart from it for economic reasons or for expediency. The resin manufacturer is therefore in a similar position to the paint manufacturer, who fondly hopes that everyone will use his product as specified.

The molder on the other hand has to consider both the necessity for making a profit and his reputation which depends to a large measure on the quality of the product he turns out. If he believes that he can use the resin without following a costly schedule recommended by the resin supplier he will do it. Also, because he has a vital interest in the products turned out and is faced with competition, he will constantly impose new requirements on the resin manufacturer such as lower prices, faster processing schedules, easier handling techniques and better properties in the resin.

This interplay between the resin supplier and the molder has produced some interesting results. The molder is faced with high costs for raw materials. At a price of 35 to 40 cents per pound for polyester resins and 40 cents per pound for fibrous glass, reinforced plastic materials would be at a distinct disadvantage compared to metal products were it not for its lighter weight, greater strength, and greater future availability. Weight for weight, reinforced plastics are generally stronger than any other known material. This factor, and other properties such as corrosion resistance, ease of forming and availability, make it a valuable material for many applications. Nevertheless, the molder is constantly under pressure to reduce costs so that applications for reinforced plastics may be broadened.

Cost of resins have been reduced over the past several years. Polyester resins were originally priced at about 55 cents per pound. Reduction in price has been accomplished in a period of rising prices. Resin suppliers have had a relatively small market to compete for and have had to absorb all their development costs. It can be expected that prices will be reduced still more as the market broadens and as resin properties more nearly approach the molder's requirements.

Typical Problems in Molding

Besides price, the molder has other requirements that depend on: Size of business, number and types of products, amount of inventory that can be carried, changing competition, type of molding processes used, and application of the end products.

To give some examples: Suppose the molder is engaged in the mass production of trays. This is an ideal application for the use of matched metal molds. Since only one product is being produced, only one resin is being handled and stored. Shelf life is not a problem because the resin can be ordered as production schedule demands. Also, because of large quantities, the molder will probably prefer to mix the resins with his own equipment in sufficient quantities for daily use only. He is, therefore, not concerned about the pot life of the resin after the catalyst and the promoter or accelerator are added.

His problems are in the behavior of the resin during the cure cycle. Trays are a very competitive item. Therefore, it is desirable that the resin has a very rapid cure cycle with minimum flow characteristics; that is, the resin stays put in the impregnated preform when under heat and pressure in the molding press. "Fat" or "lean" areas will ruin the appearance of the tray. For fast production, cured parts are pulled from the mold while hot. Therefore, at cure temperatures, the resin must be strong so as to avoid distortion of the tray. If there is danger of distortion as the tray is pulled or on cooling, an additional cooling fixture will be required to clamp the tray during cooling. From a product performance point of view, the tray should be non-porous and have a hard surface. It should withstand boiling water without distorting. (Early trays failed in service in this way.) Therefore, complete wetting of the fibers during impregnation and cure process, and stability of the resin after the product has been placed in service are necessary requirements.

A molder producing many different products in small quantities will have different requirements. Shelf life is important because many types of resins must be stocked. Resins cannot be ordered for each custom job because of uncertain schedules. Instead, resins are ordered in sufficient quantities to obtain a favorable price per pound (usually in barrel lots). It may require a year or more to use all the resins.

On the other hand, it may be preferably to buy preimpregnated fabrics from one of the many suppliers. However, the molder may be forced to pay a premium for orders in small quantities and becomes dependent on the ability of the supplier to deliver the material in time to meet commitments. Therefore, the molder prefers to use liquid resins. When it comes to processing, bag molding operations require considerable time between impregnation of the cloth or mat with the catalyzed resin and cure of the part. Lay-up of the part is usually done by hand and takes time—from several hours to several days. Pot life of the catalyzed resin is important.

Unlike the tray molder, the radome or boat molder is not concerned with fast cures (at least not to the same extent). If it has taken a day to prepare the part for molding, a few minutes more or less in the molding operation has little or no effect on costs. Many bag molders schedule work so that all parts are put in the ovens at the end of the working day and cured overnight.

The bag molder, however, may be greatly interested in the shrinkage properties of the resin and the ease of extracting the molded part from the mold without having it stick. The molded part is usually removed after cooling (parts cured overnight usually cool by morning). Since the mold area of bag-molded parts is usually considerably larger than matched-mold areas, removing the part may be difficult if it adheres to the mold. In extreme cases, the mold may be destroyed. If molded on a male mold, and there is much shrinkage, collapsing molds must be used.

Many other problems the molder faces result in specialized resin requirements. For example, if a high viscosity polyester is used because of its desirable electrical characteristics, the resin must be reduced in viscosity with styrene to impregnate the reinforcement. Styrene is not a solvent and therefore remains with the resin during the cure process. However, styrene is more volatile than the base resin,

Definitions

Accelerator–

Accelerates and improves the polymerization of a resin.

Catalyst–

Changes the rate of a chemical reaction without undergoing permanent change in its composition. Catalysts may be accelerators or retarders.

Craze–

Cracks in surface of finished product caused by an imperfect physical adjustment of the resin.

Cure–

Process of converting the liquid resin to a solid. Can take place at room temperature but usually is done at higher temperatures to hasten the process.

Epoxy Resins–

Condensation products of a dihydric alcohol and epichlorohydrin which have been further condensed by various acidic or basic substances.

Impregnation–

Wetting the fibers with a resin.

Lay-up–

Process of applying successive layers of impregnated cloth or mat in a female mold or around a male mold.

Melamine Resins–

Melamines overcome most of the objections of silicones but are somewhat less heat resistant. Used to some extent for low pressure laminates. When used with glass, can withstand service temperatures of 400-500 F continuously. Not discussed in this article because use is limited to flat laminates.

Phenolic Resins–

Mixture of phenol and formaldehyde. Phenol is obtained by the distillation of coal and also synthetically from benzene and air. Formaldehyde is generated as a gas through oxidation of methyl alcohol.

Polyester Resins–

Regulated mixtures of polyesters and polymerizable monomers. Polyesters are prepared by combining unsaturated polybasic acids such as maleic, fumaric, itaconoic and phthalic acids with polyhydric alcohols. Product of this combination, a polyester of alkyd, is then dispersed in polymerizable monomers such as styrene, diallyl phthalate, or similar compounds. Polyesters copolymerized with triallylcyanurate have high heat resistance.

Polymerization–

Polymer is a substance composed of giant molecules formed by the union of simple molecules. Number of simple molecules that unite to form a polymer molecule varies from two to thousands. Simple molecules that undergo such changes are known as monomers; their union as polymerization.

Pot Life–

Life of a liquid resin from the time the catalyst has been added to the time when it is no longer usable because of gelatine or initial cure. Life depends on temperature and humidity.

Promoters–

Small quantities added to a catalyst to increase activity.

Shelf Life–

Life of a resin when stored in its shipping container and without the addition of catalyst. Life depends on exposure to sunlight, storage temperature and humidity.

Silicone Resins–

Large variety of polymers built on a structure of alternate silicon and oxygen atoms with various organic groups attached to the unsaturated valences of the silicon atom. Produced in variety of molecular weights. Silicones are characterized by heat and oxidation resistance, good dielectric properties and water repellancy.

Solvent–

Dissolving liquid used to thin a resin (such as a phenolic resin) which may be too thick to use for impregnation. After the reinforcement material has been treated with the solvent and resin solution, the solvent is driven off by air drying or by heating. Solvents complicate processing but may be recovered through condensation or sacrificed. Polyester resins do not require solvents.

Synthetic Resin–

Amorphous, organic, semi-solid or solid materials produced by the union (polymerization or condensation) of a large number of molecules of one, two, or less frequently, three simple compounds. Properties vary widely with type and proportion of raw materials, and the conditions of formation of the resin. Typical synthetic resins are: Phenol-formaldehydes, urea-formaldehydes, indenecoumarones, alkyds, ester resins, vinyl resins. The term synthetic resin is also applied to chemically modified natural resins.

Tack–

Stickiness of reinforcement after impregnation. A tack-free cloth, for example, can be handled without sticking to the hands. Desirable condition for molding is that the impregnated cloth should be tack-free but should stick to itself to facilitate lay-up in the mold.

Wettability–

Extent to which a resin completely surrounds and adheres to a fiber.

has a disagreeable odor, is toxic and during cure may not combine completely with the polyester. This condition requires post cure of the molded part to polymerize the styrene and eliminate its odor. A resin with a lower viscosity would prevent a styrene problem.

Surface crazing is another problem. Many parts have been ruined because the resin near the surface shrinks during cure and develops small hairline cracks which impair and mar the surface.

Phenolic resins are used for high temperature applications. However, phenolics require a solvent to impregnate the filler. Preparation of the part is complicated by the necessity for first adding and then removing the solvent from the treated cloth or mat. In addition, the cure process is compounded because the solvent is rarely driven off completely from the treated stock and, unless permitted to escape during the molding process, will cause blistering and delamination. The phenolic also gives off water of condensation during the cure process which harms the laminate in the same way. This condition is not serious if high molding pressures are used because high pressure confines the vapor. The molder therefore prefers resins which do not require solvents, are non-condensing during cure but can withstand high temperatures.

Classes of Resins

A quantitative and qualitative comparison is made of the principal classes of low pressure resins in Table I. Following are some brief comments on the information contained in the table:

Polyesters compare favorably in almost all respects to other types of resins. They are economical, easy to use, and have good physical, electrical and structural properties which allow use in many applications.

Silicones fail in many respects. However, they can be used for high temperature applications.

Phenolics also have high temperature characteristics and are low in price. They require further development work because of processing and molding difficulties.

Epoxys show great promise for structural use. They wet reinforcement materials well, shrink very little during cure and can be exposed to strong chemicals. However, they are expensive and will not stand high temperatures. Developments underway will probably improve temperature resistant characteristics.

Polyester Resins

Much of the progress in polyester resin technology has been by careful blending and formulating existing resins to arrive at mixes tailored to meet specific requirements. Polyesters are available in either liquid or solid crystalline form which can be coated on cloth or mat from a hot melt or suspension so as to give a relatively dry, easily handled impregnated stock. The impregnated mat or cloth is practically tack free and can be rolled between cellophane separator sheets for storage and shipping.

Polyesters have many desirable properties: High heat distortion point, good high-temperature stability, low degree of change in electrical properties, fire resistance, high degree of chemical and solvent resistance. Polyesters also have sufficient resilience so as to minimize warpage, improve shock resistance, and eliminate surface crazing when a part is stressed or strained—all without seriously sacrificing heat distortion temperature properties. Certain types of polyesters have a very small temperature rise (less than 45C) when the material changes from a liquid to a solid. This is desirable if the part is thick—a large temperature change can cause hot spots and unequal curing stresses which may result in a cracked or crazed part.

Some polyesters have a slight change in rate of cure (drift) which takes place during the useable pot life. In certain operations, such as continuous laminating, drift in cure rate is an important factor. There are some polyesters available which have a substantially zero drift.

Polyester resins can also be supplied with both heat and fire resistant qualities. This is not to say that the resins are fireproof but that they will not support combustion when subjected to the standard Underwriters Laboratory Approval test.

To increase heat resistance, triallyl cyanurate (TAC), a highly reactive monomer, is added. This gives good stability to electrical and physical properties up to 500 F.

It is not definitely known how good polyesters are for outdoor exposure. There is no doubt that they will withstand weather for prolonged periods of time, but the discoloration when exposed to, say, ten years of sunlight is unknown and has not been determined in the laboratory. Most polyesters tend to discolor more or less when exposed to ultraviolet light although they otherwise have very good weathering resistance. However, light-stabilized resins have been developed by several manufacturers.

Polyesters can be successfully painted, provided the surface is clean, grease-free and dust-free. A suitable primer is required before painting.

Phenolic Resins

More work with phenolic low pressure applications will focus attention on their advantages. The numerous producers of the polyesters and the numerous resins available from each producer compared to the few phenolic resin producers leads most molders to almost ignore the phenolics. Also the phenolic producers have been so preoccupied with supplying the high pressure laminators that they have ignored possibilities in the newer reinforced plastics field.

Phenolics can be fabricated with glass fiber textiles in matched metal molds. They can also be used successfully in the production of glass cloth rolled tubes at contact pressure, such as glass fishing rods.

Pressures used for curing are not critical and can be varied widely. Flow properties of impregnated materials before pressing depend on factors such as: Type of resin, amount of resin applied on the material, amount of drying the resin receives after it is applied, and the nature of the material to be coated or impregnated. If the material is porous and absorbs the resin, there is less flow, hence the need for more pressure.

To cure phenolics at room temperature requires the use of resorcinol which is very costly. If resorcinol production is increased with resultant reduction in cost, room temper-

ature curing of phenolic resins would soon follow. An alternative method is to use an acid catalyst. However, this results in a more brittle finished part which is usually objectionable.

Phenolic resins have been developed which are particularly adaptable for molding at pressures from 10 to 500 psi. The excellent wetting properties of the resin make possible laminates which take advantage of the strengths inherent in the glass fibers. Material treated with this resin can be handled in dry form for low and contact pressure molding —a feature that greatly facilitates production scheduling.

Satisfactory impregnation requires control of four variables: resin, flow, remaining volatile, and drape qualities. Usual processing procedure is to thin the resin with a solvent and to dip impregnate the treated stock.

In curing the lay-up, the peculiarities of phenolic resins must be taken into account. The impregnated reinforcement contains a small quantity of residual solvents; in addition, water of condensation is produced during curing. Therefore, definite steps must be taken to provide a void-free part with maximum physical properties. It is difficult at present to obtain void-free laminates under any condition, particularly at low pressures. Therefore, for phenolic glass-fiber parts higher pressures are recommended than with polyesters. Bag molding seems to produce better results than press molding because the volatiles and the water of condensation are more efficiently scavenged under vacuum conditions. Parts made with phenolics are very dark in color tending towards cherry red or brick. This may be objectionable for some uses, and rules it out for parts requiring translucency.

Phenolic parts are unaffected by oils and hydraulic fluids and suffer only a small decrease in physical properties when immersed in water for long periods. They are completely resistant to fungicidal action. The resins have poor shelf life and must be kept under refrigeration. The pre-impregnated fabric, however, maintains its properties over an extended period.

Epoxy Resins

Principal characteristics which favor epoxy resins for industrial applications are:

Excellent adhesion resulting from a combination of several properties, including good wetting noted in the thermoplastic state, active or polar chemical groups, and the physical configuration of the molecules. However, the adhesive properties cause the epoxys to adhere to the metal of the molds. This can be prevented by using polyvinyl alcohol, teflon or cellulose parting sheets to separate the molded part from the mold.

High mechanical strength. Laminates using epoxys are generally stronger than laminates using polyesters. For this reason, epoxys are being used in structural applications.

Low shrinkage on cure. It is this property of the epoxy that results in high physical strength in the laminate.

Absence of volatile materials. Production of void-free large parts are now possible using epoxy resins. This makes possible excellent appearance in the finished product.

Good electrical properties. Although the dielectric constant and loss tangent is not as good as most polyesters, the combination of good electrical and physical properties make epoxys the choice in many systems of moderate to high frequency use.

Good combining qualities. Epoxys are being used with other resins, such as asphalt, thiokols, ureas, phenolics and melamines. Development also is being done on polyester-epoxy combinations for glass laminates to improve adhesion between glass and the polyester resin.

At present epoxys are not widely used in laminates because of high cost and lack of processing information. In addition, they are not heat resistant to the same extent exhibited by certain polyester and phenolic resins. (Limit is about 230 F, but resistance to chemical deterioration, up to 400 F is remarkable.)

Molders now have resins suitable for wet or dry lay-up and a choice of pot life from a few seconds to a few years. Curing time and temperature have been reduced for both the acid and amine type resins so that now they are comparable to polyesters.

Initially, when only the solid or very viscous epoxy resins were available, vacuum or solvent impregnation of the cloth was employed. Vacuum impregnation is costly and solvent impregnation proved to be troublesome because of lack of complete solvent release. Currently, manufacturers furnish impregnated glass cloth and mat suitable for dry lay up and subsequent cure. Shelf life is about one year. The cloth has initial tack and is uniformly coated throughout. Loadings are available up to 50 per cent resin, and a 1½ per cent tolerance can be maintained.

Epoxys lose strength above 230 F and therefore are limited for structural use at elevated temperatures. However, when cured with dicyandiamide, epoxys show good structural properties up to 400 F.

Much information must still be obtained on formulation, ageing, and other such properties before the epoxy resins can be used competitively in the structural laminating field. It is expected that epoxys will show better chemical resistance, particularly to caustics than the polyesters. Present tests indicate that compression and shear strengths of epoxy laminates are considerably better than those of the polyester-type resins.

The combinations of properties of the epoxys are unique and unobtainable from other resins. For this reason, epoxy resins will probably be more widely used.

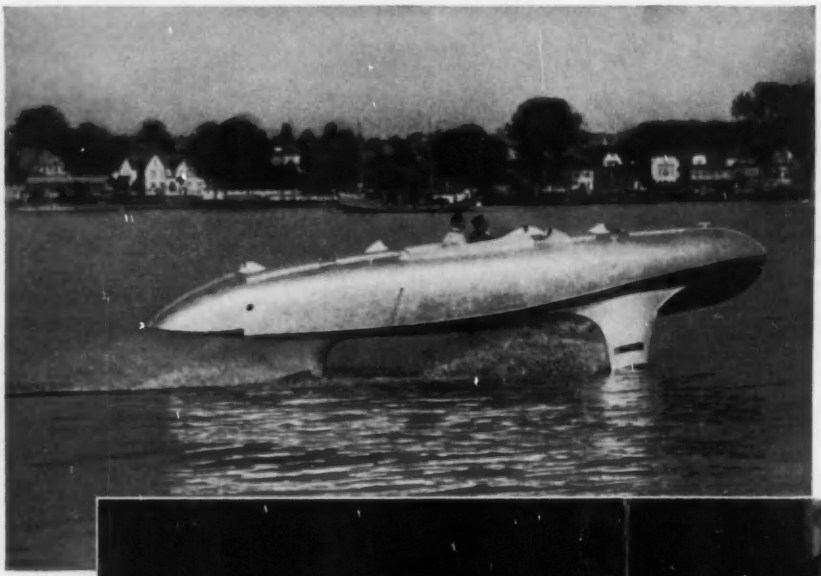
EDITOR'S NOTE—A detailed discussion of fillers for reinforced plastics appeared in "Fillers and Reinforcements," *Product Engineering*, December 1955 page 178. Included are types of fibers and powders; influence on mechanical properties, surface finish and shrinkage; effect of thixotrophy on molding requirements and control of gel time.

Useful design data on properties of glass-polyester laminates are presented in "Design Limits of Polyester-Glass Laminates," August 1954 page 161. The article includes test results showing the effect of the number of plies, contour and thickness, temperature and humidity on mechanical properties.

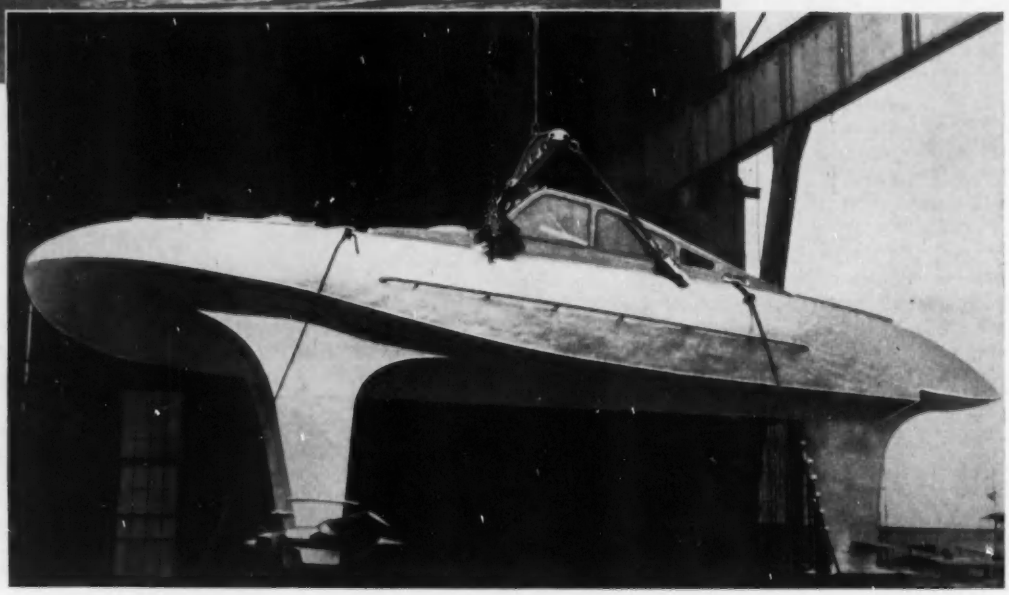
The high degree of impact, chemical resistance, low shrinkage and good adhesion properties of modified epoxy resins is discussed in "Flexible Epoxy Plastics," September 1954 page 154.

Possibility of using resin-bonded glass fibers for shock and vibration damping is analyzed in "Vibration Damping Characteristics of Glass Fiber Cushioning," February 1954 page 166.

TECHNICAL NEWS



AN EXPERIMENTAL 30 ft long hydroplane (top), built in 1953, is shown half out of the water. The test boat rose 9-10 per cent of its length above the water level during trial cruises. The 30 ft hydroplane (bottom) as it looks today, weighing 3 tons, and powered by 3 Ford V-8 motors of 90 hp each. According to Wendel, it reached 30 knots after "taking off." The smallest transoceanic hydroplane, 166 ft long, and a beam of 60 ft, will be 6 ft out of the water at a top speed of 55 knots. Cruising speed is 45 knots using 4 Diesel engines of 2500 hp each.



Hydroplanes: Future Ocean Liners?

Hydroplanes of a size (240 ft long) capable of transoceanic service at speeds twice that of the fastest passenger ships ever built, are being projected by a German inventor, Friedrich Hermann Wendel, Kieler Strasse 189, Hamburg-Stellingen. Test models (above) using a fully submerged steerable wing system, have been satisfactorily tested, and one license for the construction of overseas hydroplanes has been purchased by a Hamburg shipyard, according to Wendel.

Object of a Hydroplane—is to lift the hull out of the water in order to diminish water resistance and wave influence. The result is a speed twice that of a conventional ship while using the same horsepower engine. Experiments have been made with semi-submerged as well as fully submerged wings. According to Wendel, fully submerged wings did not give satisfactory results in tests for above water control, and stability control. Auto-stabilization of a hydroplane with partly submerged wings is possible only with calm seas, while heavy seas will cause the boat to submerge or capsize.

Wendel says that his new system of fully submerged, but steerable

transverse wings, will give a boat a maximum speed of about 110 mph, regardless of the roughness of the sea. To get higher speeds, up to 190 mph, he has developed a fully submerged steerable longitudinal wing system. With the elevation and list controlled by special wings like those of an airplane, any action of the wind or waves is neutralized, and the boat will neither pitch nor roll.

Twelve types of Hydroplanes—from 30 to 240 ft in length have been designed by Wendel who claims that they can be built at costs equal to those of conventional passenger ships of corresponding size. Wendel says that the 240 ft model would make the Hamburg-Honolulu run in 13 days, while the 195 ft ship would need only 2½ days to get from Hamburg to New York.

Wendel also has designed hydroplanes for Naval service, such as patrol boats and submarine chasers.

Process Prevents Corrosion of Aluminum Bus Bar Joints

The problem of connecting existing copper alloy materials with the new aluminum electrical conductors has been solved by a new process that gives an integrated surface of pure silver on aluminum bus bars and does away with corrosion. The process results in the replacement of surface layer aluminum crystals with those of pure silver. Just announced by the Eastern Switchgear Div., of the Federal Pacific Electric Co., Scranton, Pa., the process consists of: (1) careful cleaning of aluminum surfaces; (2) the controlled deposition of special oxides; (3) replacement of oxides with an intermediate deposition of zinc; and (4) the displacement of the zinc by silver.

The process eliminates the "bridging" oxide or other surface impurities that frequently occurs during electroplating. Uniform coatings of silver are obtained on the walls of drilled holes and other places where electrical connections are made.

The 14 steps in the process include the progressive immersion of aluminum in different chemical solutions. Ordinary dipping methods are adequate with the usual timing except for the critical stages.

Prelubricated Ball Bearings Use Felt Pads

Using felt pads saturated with oil, tests at the National Bureau of Standards, Washington 25, D. C., have indicated a new method of prelubricating ball bearings. The bearings will be used in aircraft where temperatures range from —65 to 400 F at speeds of 10,000 rpm. Conventional greases do not meet these requirements because of high starting friction at the low end of the temperature range, and poor stability at the high end.

Previous tests at these speeds and high temperatures, using grease as a lubricant, showed that the greases which performed best were those that adhered to the outer race after being thrown from the path of the balls, and then lubricated by slow bleeding. This suggested the use of felt rings, saturated with oil, as a method of bleeding oil to the bearings. Actually, the felt would be used instead of a soap or other thickener to supply oil slowly to the bearing without further addition of oil to the felt.

Metal holders for felt rings made from ¼ in. thick felt were designed so that the assemblies could be fitted to each side of a standard ball bearing. No. 204 (SAE No. 20BC02) ball bearings with a 20 mm bore were used as test bearings. Different mineral and synthetic oils with various additives were tested.

The bearing was installed like a greased bearing, but with an oil-soaked felt pad on each side. The pads are so designed and positioned that the felt contacts the outer race, but does not contact either the inner race nor the ball separators of the bearing. All tests were run at 325 F and 10,000 rpm.

Of the different types of oils tested, di(2-ethylhexyl) sebacate containing tricresyl phosphate and other additives seem to be the most promising. The length of the test was 1005 to 1246 hr before failure. Addition of a mild extreme-pressure additive (acid phosphate) increased the test length to 1781 hr. Conventional prelubricated ball bearings filled with a typical prepacking grease failed after 178, 307 and 330 hr respectively after endurance runs under the same conditions.

The wool felts used in these tests become charred at 325 F after operating over 1000 hr. For operation above 325 F, pads from other fibers such as metal, glass, or teflon are being considered. The series of experiments is being sponsored by the Navy Bureau of Aeronautics.

Connect Two Computers To Share Single Problem

Two high speed electronic digital computers were interconnected at the National Bureau of Standards to work cooperatively on a single problem. Coordinated programs were read into both machines to show that in program-controlled machine intercommunication, two digital computers with unlike operating characteristics could work together, provided that one of them has the necessary control flexibility. The program used in the test was a new method of sorting merging, and posting of records.

For such an operation where both the information and the exchange of control are transferred between the two computers, programmed control vs automatic interruption is important. Provision must be made in the programming for the automatic interruption of a program in process in order to turn to the new information just received from another system.

The experiments were carried out at the NBS data processing systems laboratory as part of a cooperative program with the Navy Bureau of Supplies and Accounts to investigate the application of such techniques to the problems of supply management.

The two computers used were SEAC and DYSEAC. The latter was designed at NBS for the Dept. of Defense to serve as the nucleus of a generalized feed-back control network. It has operating features which causes it to respond automatically to information from remote external devices. These features include manual-monitor facilities, program control flexibility and special input-output controls.

A CONVENTIONAL 1956 PLYMOUTH, powered by Chrysler Corporation's experimental automotive gas turbine gets ready for its cross-country test. Chrysler claims fuel economy equal to piston engine cars. Inset shows diagram of the gas turbine.

Automotive Gas Turbine Gets Road Test

Discounting the words "Turbine Special" on the white 1956 Plymouth above, the only indication that the car is of special design is the odd-shaped exhaust pipe directly under the number plate. This is Chrysler Corporation's test car, powered by an experimental gas turbine engine, which was given a 3000 mile cross-country endurance test. While Chrysler feels that it has licked the major problems in designing a gas turbine for automotive use, the commercial production of gas turbines for cars is some time off, because of: (1) the need for less expensive, non-strategic materials for engine parts subjected to intense heat (turbine wheels and blades), and (2) refinements in manufacturing techniques needed to produce automotive gas turbines in quantity.

Construction Details.

• The long-standing problem of reducing the exhaust temperature has been solved with a heat regenerator which Chrysler says results in an exhaust temperature lower than that of a conventional piston engine. Another gain here is a reduction in fuel consumption.

• There is a weight saving of almost 200 lb compared to a piston engine of comparable power, and with 80 per cent fewer parts. The gas turbine was designed to fit the engine compartment of a standard Plymouth, and with its set of reduction gears is 32 in. long, 33 in. wide, and 28 in. high.

• Chrysler's turbine engine is rated at 120 shaft horsepower, but delivers about the same performance to the rear wheels as a piston engine rated at 160 hp connected with a transmission.

• Conventional auxiliaries missing on the gas turbine are the cooling fans, the air cleaner, water pump, and carburetor.

• Torque is greatest at breakaway from a standing position, and falls off as car speed increases. With a piston engine, torque increases from zero at the start to a maximum in the mid-speed range. The car-driving turbine is connected directly through gear trains to the rear wheels. A transmission is used in the present test model only to provide a reverse gear.

• Fuel for the experimental gas turbine is gasoline, but kerosene or heavy fuel oil may be used. Fuel consumption rates of 15 to 17 miles per gal have been reached at steady driving speeds of 30 to 40 mph. Chrysler claims that their studies indicate that further developmental work will produce a thermal efficiency as high as 40 per cent in a regenerative gas turbine. Present car engines

JAMES C. ZEDER, left, V.P.-Engineering, and George J. Huebner Jr., Executive Engineer in charge of Research, with the latter holding a duplicate of the power turbine wheel used in the automotive gas turbine. Speed of the compressor turbine at idle is 20,000 rpm; maximum design speed of the driving turbine is about 50,000 rpm.

have a top efficiency of about 24 to 27 per cent.

• Idling speed of the compressor turbine is 20,000 rpm, while the car-driving turbine is near zero. The car-driving turbine rotates at speeds up to 50,000 rpm. Starting is by conventional methods in that the starter motor turns the compressor to about 10,000 rpm before the fuel is ignited.

George J. Huebner, Jr. of Chrysler's Research Dept. says that the regenerator is responsible for the engine's fuel economy, and that during the trip, the regenerator was operating at efficiencies of 86 per cent.

Change in Military Standard Thickness Gage Numbers

A change in the military standard in thickness and gage members of all uncoated and metal clad sheet and strip metals has just been announced by the U. S. Air Force, the Bureau of Aeronautics, and the Aircraft Industry. The new standard, to be used in aircraft practice, will offer a simplified system for designating thickness. The announcement was made by the Air Materiel Command, Office of Information Service, at Wright-Patterson Air Force Base, Ohio.

The reason for the change is to eliminate the confusion caused by the various gage numbers used in the past, and to increase the availability in warehouse stocks of those thicknesses commonly required. Also, it will reduce the stock inventory and permit the interchangeability of different metals in design.

Brig. Gen. C. H. Mitchell, deputy director of production, AMC, said mills have indicated that any desired thickness of sheet or strip can be supplied within their manufacturing limits, subject to existing tolerance limitations. The standard applies to nominal thickness. Tolerance should agree with existing Federal and Military standards, and otherwise to applicable industry standards.

Military Standard 33528 (ASG)—the new standard—is applicable to all new designs. The next revision of ANC-5 Design Bulletin, "Strength of Metal Aircraft Elements," will incorporate the new standard.

ASTM Giving Special Attention to Nuclear Problems

Taking cognizance of the coming problems in nuclear energy development, particularly in the construction of reactors, the American Society for Testing Materials will devote much of its time to the setting of standards for materials and for testing of materials used in this field. A special Administrative Committee on Nuclear Problems has been organized by the Society.

Its job will be to: (1) advise the technical committees of the Society on nuclear problems pertinent to their respective scopes; (2) stimulate the undertaking of research and standardization projects, specifically related to nuclear energy, on the part of the technical committees; and (3) review periodically the status of the work.

As the first step in coordination, the ASTM Committee E-10 on Radioactive Isotopes will be asked to expand its title and scope to investigate, promote, and advise on techniques and standards for measuring changes in properties and constitution of materials as a function of radiation exposure.

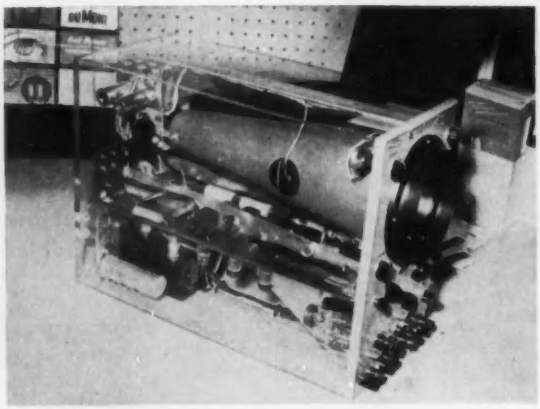
In addition, the Special Administrative Committee will establish a list of materials used in reactors as a basis for future technical committee activities. Information will be obtained from the technical committees on current and planned activities regarding engineering materials in nuclear reactors (including nuclear fuels), as well as the property changes in engineering materials exposed to nuclear radiation.

The Atomic Industrial Forum and ASTM will sponsor a symposium on radiation effects on materials at the ASTM Pacific Area National Meeting in Los Angeles, Sept. 17-21.

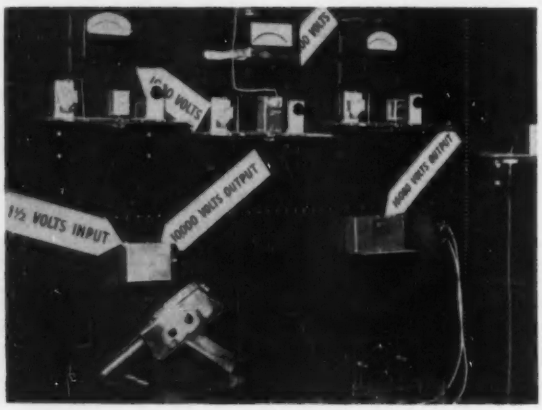
Engineers Jam IRE Show

Regarded as the largest Industrial Show in the world, the Radio Engineering Show and the Institute of Radio Engineers Annual Convention lived up to its name by playing before a packed house of more than 40,000 at the Kingsbridge Armory in New York City. At the convention, 715 exhibits overflowed into the nearby Kingsbridge Palace. In addition, 275 papers were presented in 55 technical sessions. There was a special symposium on the U. S. part of the earth satellite program, and much time was devoted to discussions and demonstrations of color television.

Just a few of the new developments seen at the show are shown in the pictures below.

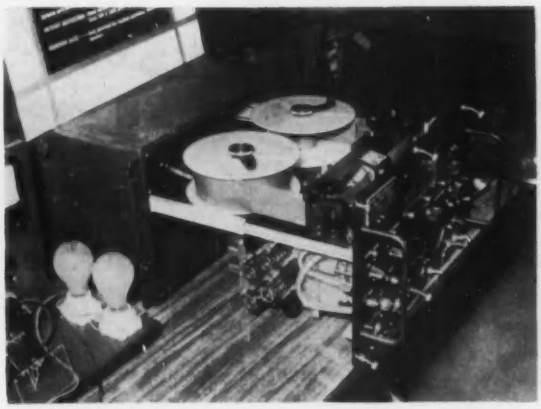


MODULAR UNITS, developed by ACF Electronics, are used in the construction of an experimental cathode-ray oscillograph made by the Allen B. Du Mont Labs., Inc., 750 Bloomfield Ave., Clifton, N. J. An outgrowth of the Project Tinkertoy mass production technique developed at the National Bureau of Standards, the modular design uses components printed on ceramic wafers. Each module represents a complete circuit element, and is connected by printed circuitry. Du Mont claims a "first" in applying this type of design to electronic testing equipment. The modular unit here is identical in performance to Du Mont's model 350, a low frequency oscillograph.



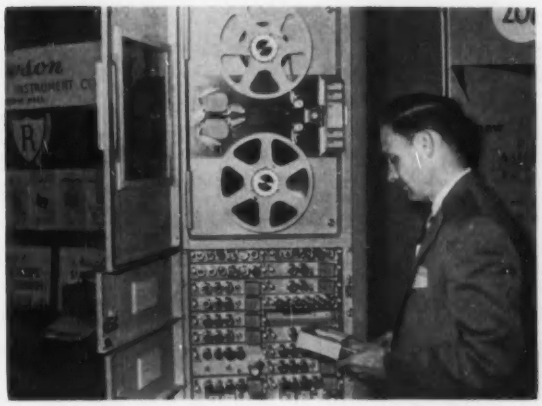
TRANSISTORIZED POWER SUPPLY UNITS, capable of delivering 20,000 volts can be held in the palm of the hand. As sign indicates, a 1½ volt input and 10,000 volt output. Made by Universal Atomics Corp., 19 East 48th St., New York 17, N. Y., the power supply units come in four main categories: for Tubes (Geiger, scintillation counters, dosimeter chargers, etc.), output voltage range from 20 to 2500, and current up to 0.5 ma; for Guided Missiles, battery operated oscilloscopes, picture tubes, and an output voltage range from 20-7000 with current up to 0.5 ma; for Infra-red applications, scanners with output voltage range from 6000 to 20,000 and current up to 50 microamps; for Communications systems, computers, ordnance uses, etc., with output voltage range from 20 to 1500, and power range from 0.1 milliwatts to 10 watts. In left foreground is lightweight, transistorized Geiger counter.

DESIGNED FOR MANUFACTURING CONCERNS, offices, banks and governmental agencies, this Facsimile system is almost a duplication of the one made for the United Press for its transmission of news photos. The Allen D. Cardwell Mfg. Corp., Plainville, Conn., expects the system to be used for the immedate transmission of engineering drawings, orders, price changes to widely separated manufacturing plants. As the copy is fed into the transmitter at left, it is illuminated by fluorescent lamps and an image is formed by the lens system at one surface of the scanning disk. The figure is scanned and the light signal is picked up by a photo multiplier tube whose circuit provides logarithmic response. The signal is amplified to modulate a carrier generated in a local oscillator. Adjusting for black and white copy contrast, the signal is further amplified and transmitted.



A 24 HR TAPE RECORDER which can record two channels simultaneously is being used by the U. S. Air Force for 24 hr monitoring service of ground-air conversations. A single reel of Mylar tape, 2 in. wide and 960 ft long is used, travelling at the rate of 8 in. per min. Four scanning heads per channel scan almost perpendicular to the edge of the tape. Output distortion and total harmonic distortion not more than 5 per cent from 400 to 2000 cps. Manufacturer is Olympic Radio & Television, Inc., Long Island City, N. Y.

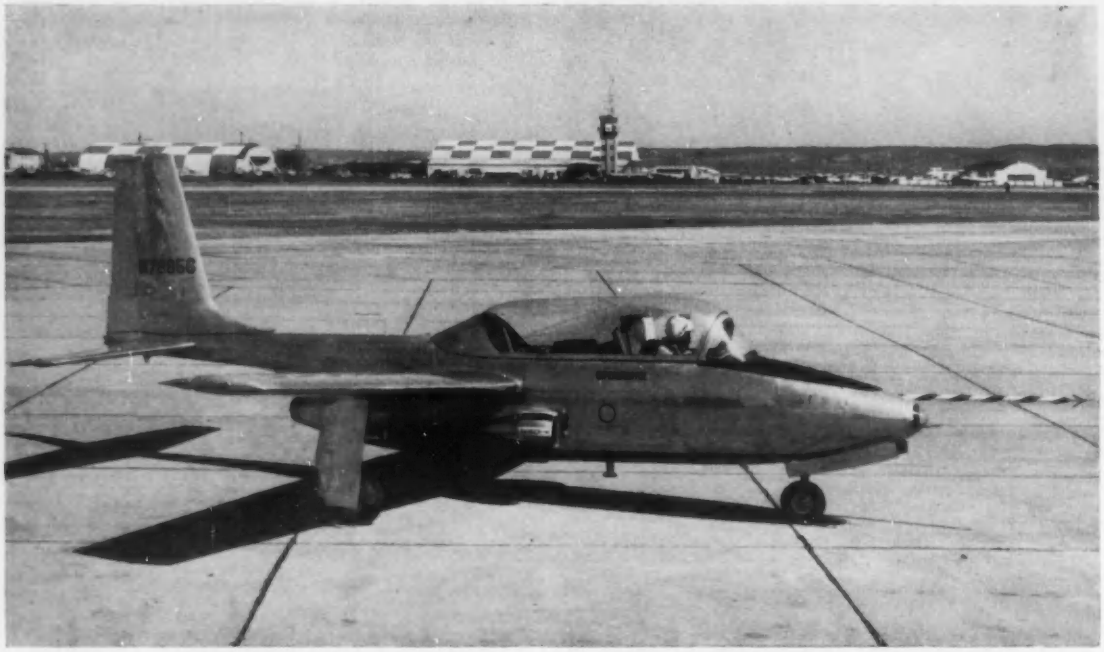
SLOWED DOWN TO AN OUTPUT OF about 100 in. of tape per min., this Electrographic Printing Technique developed by Burroughs Corp., Detroit 32, Mich., can record characters at rates greater than 5000 characters per second. The only motion involved is the continuously moving paper under the printing head. The process uses a controlled charge source to form small charged areas on the high-resistivity surface of the coated paper. The electrostatic image formed is made visible with a powder, and made permanent by passing the inked paper over the temperature controlled hot plate.



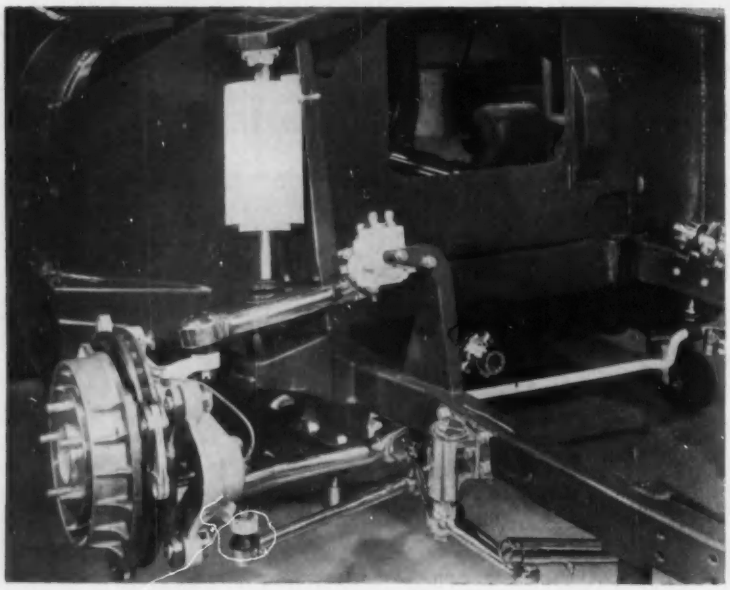
THE NEW FR114 MODULAR MAGNETIC RECORDER with plug-in interchangeable amplifiers for Direct, FM and PWM recording to fit individual test needs. Available in models with from 1 to 14 tracks, tape transports provide six standard speeds of $1\frac{7}{8}$ to 60 ips. The FR114 will record and reproduce signals in d-c to the 100 kc range. With the modular construction, any record amplifier can be exchanged with any other type record amplifier, and any reproduction amplifier with any other type reproduce amplifier. The speed selection on the front of the transport permits speed changes without any manual changes. The FR114 is being used with the tape controlled machine tools, and for government telemetering and data gathering applications. Manufacturer is the Ampex Corp., 934 Charter St., Redwood City, Calif.

UNDERWOOD'S CORPORATION'S ELECOM 125 File Processor which automatically sequences, selects, collates, and separates information recorded on tape. Used for billing, taking inventory, figuring commissions, and other routine functions, it relieves its companion computer of handling the simple business data operations so that it may be used for fast selective computation. The file processor itself is operated by a punched-tape reader or typewriter keyboard which keys the file processor for operations about to take place. The operator selects the desired operation at the control panel, and after the pattern is selected at the keyboard, the rest of the operation is automatic. Up to 30 items can be processed in a second, and results are recorded on magnetic tape which can be fed to a high-speed printer or computer.

THE NEWS IN PICTURES

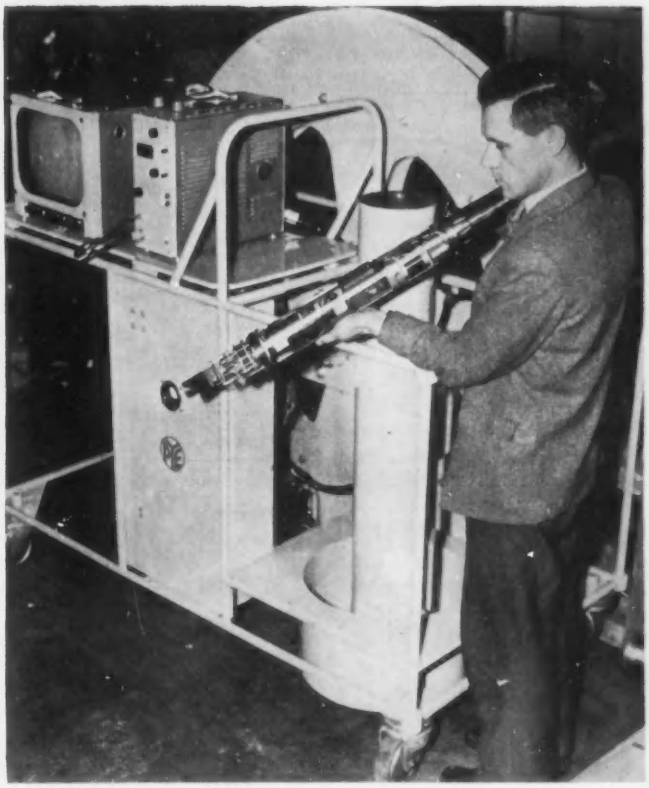


MODEL 51 JET TRAINER built by Temco Aircraft Corp., Dallas, Texas, boasts a top speed of 300 knots at 15,000 ft, which Temco says is 50 mph faster than any other fully equipped single-jet primary trainer. The turbo-jet engine used is Continental's YJ-69-T-9 with 920 lb of thrust. Wing tips, stabilizer tips, tail cone, and engine intake ducts are of molded fiberglass. A feature from the maintenance side is that the engine has been surrounded completely with secondary structure, permitting a complete engine change from removal to tune-up in 20 min. Normal fuel load is 119 gal, but a total capacity of 165 gal is possible with bladder type fuel cells in the leading edge of the wing center section, and in the outer wing panels. Gross weight: 4137 pounds. Wing span is 29.8 ft; overall height is 10.8 feet.

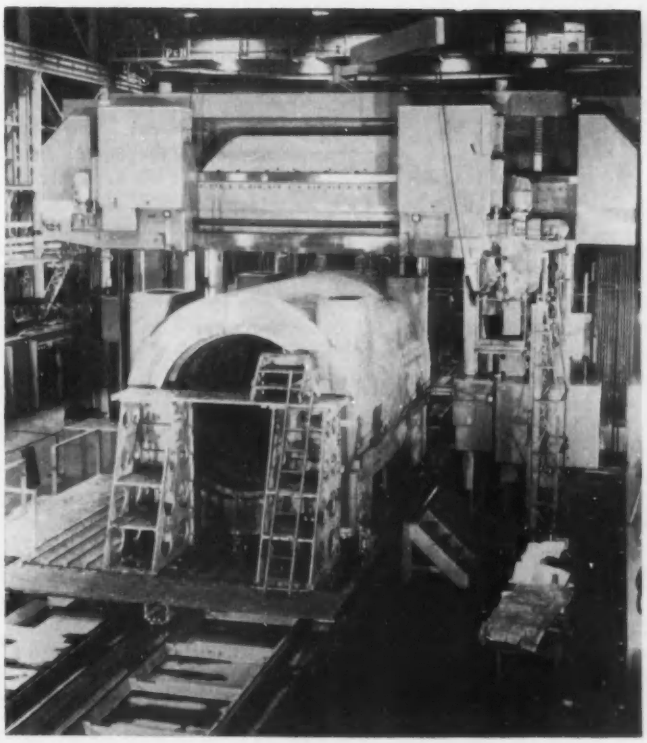


ONE UNIT OF General Motor's new air/oil suspension system (white cylinder) shown here on the right front wheel of the Firebird II. Designed to take the place of conventional springs and shock absorbers, the suspension unit is 8 in. long and 4½ in. in diameter. Present weight is 13 lb, but this is expected to be reduced somewhat in mass production with stamped end plates. At far left in the picture is the metal-to-metal brake, minus the wheel. According to reports, the brake has excellent efficiency in upper temperature ranges caused by a series of high-speed stops, is unaffected when wet or dirty, and has no fade characteristics. Six metal pads, molded from powdered metal, comprise the friction surfaces. There are two hydraulic wheel cylinders per wheel. In both the 16 in. and 14 in. brake the fire rim is flat (no drop center) which allows more room for braking surface.

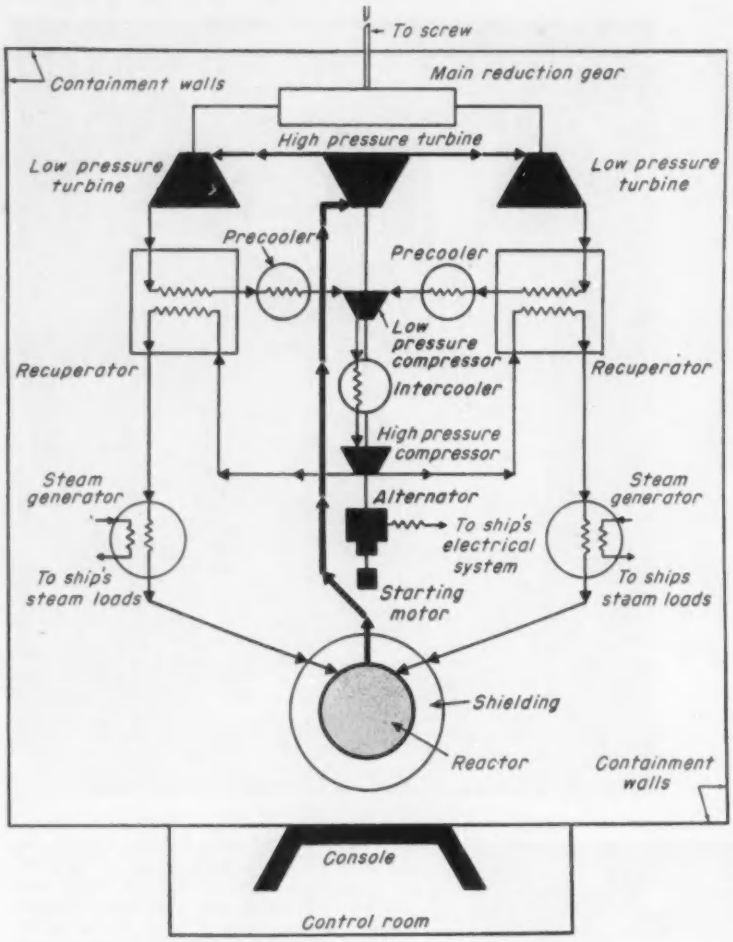
GIVING COMPACTION IN EXCESS OF that obtained with a 5 ton dead weight roller, this hand-operated self-propelled, 28 in. vibrating roller, weighs only 675 lb and can be maneuvered in places where heavier rollers cannot be used. Another 32 in. self-propelled model weighing 1700 lb gives greater compaction than a 10 ton dead weight roller. The manufacturer, Essick Mfg. Co., 1950 Santa Fe Ave., Los Angeles 21, Calif., says that these models are effective in compacting granular materials in layers from 10 to 24 in. thick. A 54 in. model weighing 3225 lb and pulled by bulldozer, can roll the finished surfaces. The range of vibrations is 3600 to 4500 per minute.



EXPOSED TO TEMPERATURES OF 400 F, this television camera keeps an eye on the inside of an atomic reactor furnace. Protected by a stainless steel casing, the 30 in. long camera is cooled to a temperature of about 110 F by pumping carbon dioxide to it through the rubber housing of the control cables. After being tested by the designers, Pye Ltd., Cambridge, England, the television camera will be installed at the British atomic power station at Calder Hall, Cumberland. In the background at left in the picture are the controls and receiving set mounted on a portable trolley.



NOW UNDERGOING FINAL TESTS at the Ingersoll Milling Machine Co., Rockford, Ill., is the world's largest milling machine. The machine stands 35 ft high and is capable of working on metal parts 18 ft wide, 16½ ft high and over 50 ft long. Interrupted cuts can be made at high feed rates, yet the joint surfaces will be machined to tolerances of 0.003 in. Horizontal cutting heads are at both sides, and two vertical cutting heads are mounted on the adjustable crossrail above the work tables. Each head has a 100 hp drive motor. Work pieces are carried on two 17 ft wide tables which move on 112 ft bedways. The tables are 22 and 30 ft long. While work is being machined on one table, the other table at the end of the machine is being loaded or unloaded. Chips from the machining will be carried away by power conveyors in the foundation under the machine.



Bids Received for Tanker Nuclear Power Plant

Thirteen companies have submitted bids to the Maritime Commission for the design of a nuclear propulsion system to be installed in a tanker type vessel by June 1959. Nine of these companies had proposals for preliminary studies on nuclear systems more advanced than the one to be installed in 1959. One of this latter group, Ford Instrument Co., Div. of Sperry Rand Corp., Long Island City 1, N. Y., submitted the design shown in the schematic above—a combination of a gas-cooled reactor with a closed-cycle gas turbine power plant. The system is similar to the one developed by Escher Wyss Ltd. of Zurich, Switzerland, and in use in some power plants in Europe.

In Operation—the high temperature, high pressure gas (nitrogen) leaving the reactor at about 330 cu. ft. sec. is partially expanded in the high-pressure turbine, which drives the high and low pressure compressors, and the alternator which supplies electricity for shipboard use. From the high pressure turbine, the gas is further expanded in two low pressure turbines which are geared down to the propellor shaft. From the low pressure turbines, the gas, still at high temperature, flows through the recuperators, where some of the heat is recovered, then through the precoolers, where the gas is cooled.

The low-temperature low-pressure gas next passes through the low-pressure compressor, an intercooler, the high-pressure compressor, and to the recuperators, for preheating. From here the gas goes through the steam generators where some of the heat is used to generate steam for ship services. The gas returns to the reactor where it picks up the thermal energy for closed-cycle operation.

The gas temperatures remain roughly constant to all loads, as do the pressure ratios, gas velocities, and peripheral speed of the turbine-compressor set. Regulation of the reactor outlet gas temperature during load changes is accomplished automatically by the reactor control system. With slow fluctuations in load, gas is either added or withdrawn from the cycle to get the necessary energy supply to the power turbines. With this method, operating efficiencies are kept high even down to below ¼ speed. For fast maneuvering, a bypass around the power turbines is opened.

Choice of Working Fluid—and coolant was narrowed down to nitrogen and helium. But in the final analysis, nitrogen is a good compromise toward minimizing heat transfer surface area and required copressor power. Also, its radioactivity is low enough to eliminate any secondary shielding. Nitrogen is easier to get than helium, and less expensive.

With helium, the heat transfer surfaces would be more compact because of higher conductivity and a higher Reynold's number. However, the specific heat of helium is about five times greater than that of nitrogen; therefore, more stages in the turbines would be necessary. Efficiencies with helium would be slightly higher than with nitrogen, and might result in simpler fuel elements.

Gas temperature—at the reactor outlet is 1300 F; pressure is 520 psi. H.P. turbine outlet temp. is 1030 F, and pressure 260 psi. L.P. turbine discharge temp. is 820 F; temp. 130 psi. Compressor inlet temp. is 80-90 F. Efficiency of power plant is 35 per cent.

Safety Advantages—of a gas-cooled system are that no sodium or other chemically active material is in the system; no pressurized water that can flash into radioactive steam; no corrosion of fuel elements by coolant; medium working pressures; and low coolant radioactivity. (For further details on reactors, see page 138.)

COMING EVENTS

MAY 14-17

First Design Engineering Show, Convention Hall, Philadelphia, Pa. The first show of its kind, it will be devoted to, and will have on exhibit, all types of original equipment which go into the manufacture of a finished product. The show is an outgrowth of another show called The Basic Materials Show.

MAY 15-16

Industrial Nuclear Technology Conference, co-sponsored by *Nucleonics* magazine, a McGraw-Hill Publication, and Armour Research Foundation to be held at Armour Foundation, 35 West 33rd St., Chicago 16, Ill. The meeting will be aimed at an industrial audience, and will cover uses of radioactive materials in many industries. Radiation sources and nuclear instrumentation will be covered.

MAY 16-18

Society for Experimental Stress Analysis, Spring Meeting, William Penn Hotel, Pittsburgh, Pa. Some of the papers to be delivered: A new type of Electrical Resistance Extensometer; A procedure for the Elastic Stress Analysis of Threaded Connections, Including the Use of an Electrical Analogue; Experimental Research on Aircraft Structures at Elevated Temperatures; A simplified method of obtaining Principal Stress Information from Electrical Resistance Strain Gage Rosettes; Developments in the Grid Method of Experimental Stress Analysis; and many others. For further information write: Dr. M. M. Leven, Westinghouse Research Labs., Buelah Road, Pittsburgh 35, Pa.

MAY 17-19

30th Engineering Industries Exposition and Convention of the N. Y. State Society of Professional Engineers, Statler Hotel, New York, N. Y. The Consolidated Edison, one of a number of exhibitors, will show a scale model of the reactor being constructed at Peekskill to supply power generated by atomic energy to New York City. General Omar Bradley and Vincent G. Terenzio, P. E. of the N. Y. City Board of Water Supply, will receive the Society's awards for distinguished service to the engineering profession.

MAY 23-26

National Society of Professional Engineers, Annual Meeting, Ambassador Hotel, Atlantic City, N. J. A feature of the meeting will be a series of conferences dealing with engineers in government industry education and consulting practice.

MAY 24-25

Second Production Machine Tool Hydraulic Forum, Engineering Society of Detroit Building, Detroit, Mich. The second forum for the Machine Tool Industry to be sponsored by Vickers, Inc., its purpose is to promote further improvement of hydraulic components and systems through an open exchange of information. Taking part in the open forum discussions will be representatives of machine tool builders, users, hydraulic accessory manufacturers and Vickers personnel. The agenda is prepared from questions submitted in advance by forum participants, and will cover the full range of industrial hydraulics. Attendance is by invitation only.

MAY 28-30

Annual Spring Meeting of the National Fluid Power Association, the Greenbrier, White Sulphur Springs, West Virginia. The first day will be devoted primarily to marketing subjects, the second day to public, industrial and government relations, and to education and other subjects of general interest, and the third day to technical matters of which trends and progress toward standardization of terminology, rating factors and limited dimensional standards will predominate. Further information may be obtained from Barrett Rogers, Executive Sec., 1618 Orrington Ave., Evanston, Ill.

JUNE 3-6

40th Annual Meeting, American Gear Manufacturers Association, the Homestead, Hot Springs, Va.

JUNE 4-9

6th International Mechanical Engineering Congress, Paris, France. Further information may be obtained from the Permanent Secretariat of the Congress, 11 Avenue Hoche, Paris VIII, France.

JUNE 6-8

10th Annual Convention of the American Society for Quality Control, Palais du Commerce, Montreal, Canada. More than 80 speakers from the U. S., Europe, and Canada will address the convention. This is the first exhibit held outside the U. S., and present plans include 50 exhibits showing recent developments in gages, calculators, and other devices.

JUNE 11-15

National Plastics Exposition, of the Society of the Plastics Industry, Inc., the Coliseum, New York City. The latest plastics end-products and raw materials, new developments in machinery, equipment, tools, dies, molds, and manufacturing processes will be displayed. A Conference on Plastics will be held at the same time.

JUNE 14-16

Applied Mechanics Conference of the ASME, University of Illinois, Urbana, Ill.

JUNE 17-21

ASME Semi-Annual Meeting, Hotel Statler, Cleveland, Ohio.

JUNE 18-29

Special Summer Program in "Creative Engineering and Product Design," Massachusetts Institute of Technology, Cambridge 39, Mass. The program will present some of the techniques of creative problem solving. Full details and application blanks from the: Summer Session Office, Rm. 7-103, at the above address.

JUNE 25-27

Symposium on Methods, Materials and Processes involved in the Uses of High Temperatures, co-sponsored by the Stamford Research Institute, and the University of California, at the University's campus in Berkeley, Calif. More than 300 people are expected to attend.

THE SHORTAGE OF SCIENTISTS AND ENGINEERS:

How Critical Is It?

The United States is running into a serious shortage of scientists and engineers. There is no novelty in this observation. It has often been made in the last few years. And there has been mounting alarm about what this shortage may mean for both our national security and our prosperity.

There would be great novelty, however, if general agreement were attained on such important matters as the size of the shortage, the extent of the damage it threatens to inflict, and the best ways to eliminate it. The purpose of these editorials is not to provide this novelty, but to ventilate some of the key aspects of the shortage of scientists and engineers.

This first editorial in the series is designed to throw light on the over-all dimensions of the shortage. Others to follow will be addressed to such questions as:

- How serious is the threat to our economic well-being and to our national security?
- What needs to be done to prevent the shortage from becoming critical?

Rise Has Been Rapid

The problem is *not* that we have been producing a small number of engineers and scientists. Indeed, the number has risen sharply. We now have a working force of more than 600,000 engineers, over twice as many as the 286,000 there were in 1940. And we have about 250,000 scientists (chemists, physicists, biologists, geologists, mathematicians, etc.), compared to only 92,000 in 1940. About one in 148 persons in the labor force of 1940 was a scientist or engineer; today the ratio is about one in every 80.

In research and development work, where highly creative scientific minds are required, there has been fully as rapid a rise in employment of scientists and engineers. Fewer than 90,000 were employed in research and development fifteen years ago; the total now exceeds 200,000.

—But Not Rapid Enough

Despite this rapid increase in the number of scientists and engineers—at a rate much faster than the increase in the labor force as a whole—the needs of industry, government and education for technically trained people have risen even more sharply.

The principal reason for this mounting demand is the prodigious growth of research in the last 15 years. From a total of only about $900 million spent on all types of research in 1941, the annual expenditure rose to over $5 billion by 1953 (the latest estimate available). Over two-thirds of the research is done by private industry, mostly to develop new and better products and to find new and better methods of production. Most of the rest is performed by the government, largely to develop improved and inevitably more complex scientific weapons.

One aircraft company has found from its own experience that it required 17,000 engineering manhours to develop a typical fighter plane in 1940. The requirement is now about 1.4 million engineering manhours. Development of the typical fighter plane of 1960 will require well over 2 million engineering manhours.

In this dramatic example, the need for engineering services for a basic piece of military equipment soared 80 times in 15 years. It is an indication of why the demand for more and more technically trained men and women has outstripped even the imposing increase in scientific and engineering manpower of the last decade and a half.

Size of the Gap

Exactly how great the gap is between the available supply of scientists and engineers and the number required, it is impossible to say. In some instances technical talent undoubtedly could be better used than it is now. And part of the shortage might "disappear" if higher salaries had to be paid. (These questions will be discussed in later editorials.) But informed estimates of the approximate size of the gap can be given.

- According to the best available information, from estimates by the Engineers' Joint Council and the U. S. Bureau of Labor Statistics, **the minimum need for engineers from graduating classes is 40,000 each year for the next ten years.** Last year we graduated only 23,000 engineers, just about enough to cover replacement needs without allowing for any expansion of the number of active engineers. Projections made by the U. S. Office of Education indicate that we shall probably not have a class of 40,000—the *current* annual requirement—until 1963.
- According to Dr. Howard Meyerhoff, executive director of the Scientific Manpower Commission, **there is now a shortage of about 20,000 scientists.** Last year the number of doctoral degrees in the natural sciences, almost a prerequisite for research work, was only 5,000. Dr. Meyerhoff estimates that the shortage of scientists will rise another 30,000 by 1960.

More Needed As Teachers

Not all of the graduates with scientific and engineering training, furthermore, will work as scientists and engineers—that is, by performing research and giving it practical application. Such training is now necessary in many sales and management positions. And more of our technically trained men and women must remain in educational institutions as teachers if the quality of engineering and scientific education is to be maintained. A survey in 1954-55 by the National Education Association showed that, out of 277 universities, state colleges and large private colleges, nearly one-third *already* had unfilled vacancies in engineering and three-fourths had vacancies in physical sciences.

The dimensions of the shortage of scientists and engineers can be summarized as follows: **Despite a substantial rise in the trained manpower available, the needs of industry, the government and education have risen still faster. The best information indicates that, on the basis of current and anticipated needs, our recent yearly rates of production of slightly over 20,000 engineers and about 5,000 PhD's in natural sciences could be doubled without closing the gap entirely.**

The disturbing implications of this shortage for our national security and our prosperity and some practical suggestions for eliminating it will be the subjects of subsequent editorials in this series.

This is one of a series of editorials prepared by the McGraw-Hill Department of Economics to help increase public knowledge and understanding of important nationwide developments of particular concern to the business and professional community served by our industrial and technical publications.

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Donald C. McGraw

PRESIDENT

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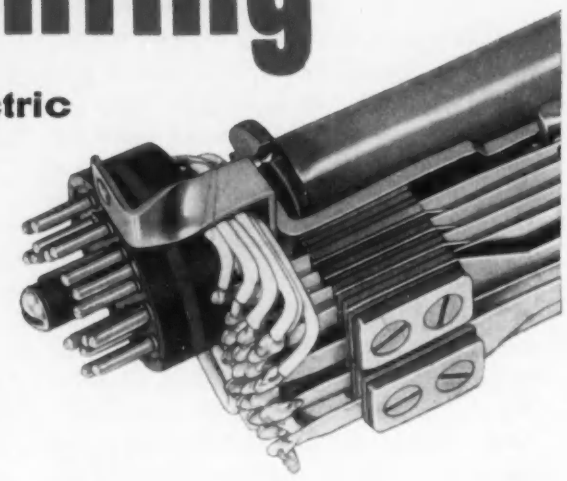
you can have the advantages of

plug mounting

in all these Automatic Electric

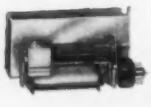
relays



CLASS A:
The "all-purpose" relay for use where first cost is important. Gives long, dependable service. Size: 4⅜" x 2⅜" x 1⅞".

CLASS B:
Made for extremes of long service life and dependability — often exceeding 400 million operations! Size: 4⅜" x 2⅜" x 1¼".

CLASS F:
Low operating power makes this relay especially desirable in a.c. circuits where relays function without specified operate or release time delays. Size: 4⅝" x 1 15/16" x 1¼".



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Provides maximum timing in a "small-as-possible," low-cost relay. Compact, light, resistant to shock and vibration. Size: 3¼" x 2⅞" x 1 13/32".

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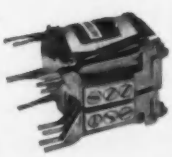

For any application, you can choose an Automatic Electric relay—a top-quality relay in every way—with the additional advantages of *plug mounting:*

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GENERAL TELEPHONE SYSTEM

Selecting Motors for Fans and Centrifugal Pumps

C. G. VEINOTT
Reliance Electric & Engineering Company

Nomogram in Fig. 1 gives relationships between torque, power and speed for applications where the torque varies as the square of the speed and power varies as the cube of the speed (such as in fans and centrifugal pumps). Torque scale is given in lb-ft (usually for integral hp motors) and oz-ft (for fractional hp motors). Power scale is in watts, kilowatts and hp. Speed scale is divided into two rpm scales--upper scale for integral hp motors and lb-ft scale of torque--lower scale for fractional hp motors and oz-ft scale of torque. If desired to read torque in oz-ft when upper rpm scale is used, multiply actual scale reading by 10 (see Example 1); if desired to read the torque in lb-ft when the lower rpm scale is used, divide actual scale reading by 10 (See Example 5). Speed scale is also marked with most common full-load speeds of induction motors with poles and frequency corresponding to these speeds.

The reference axis has been so drawn that if a straight line is turned about any point on it, the torque indicated will be directly proportional to the square of the rpm, and the power proportional to the cube of the rpm.

Sample Problems

Example 1: What is full load torque of a 1.5 hp, 1160 rpm motor? **Solution:** Straight line across 1.5 and 1160 rpm gives 6.8 lb-ft (oz-ft scale shows 10.9, so oz-ft torque would be 109).

Example 2: What is full load torque of a 1 hp, 2 pole, 60 cycle motor? **Solution:** This rating normally considered a fractional hp rating; line across 1 hp and 2 poles 60 cycles gives 24.4 oz-ft. If considered as an integral hp rating, line across 1 hp and 3500 rpm on integral horsepower rpm scale gives 1.5 lb-ft.

Example 3: Dynamometer test on a fan showed that it requires 11 lb-ft to drive in free air at 1160 rpm. (A) What hp is required? (B) What power and torque is necessary to drive fan at 1750 rpm? **Solution:** (A) Line across 11 lb-ft and 1160 rpm gives 2.4 hp or 1.8 kilowatts. (B) Extend line to reference axis obtaining intersection point. From this point lay straight line across 1750 rpm to obtain 6.2 kilowatts or about 8 hp. Torque is read on torque scale as 25 lb-ft.

Example 4: A unit heater fan is designed to require $\frac{1}{4}$ hp at 1150 rpm. Assuming same fan to be used, what are nearest available speeds and what hp is required at each speed? **Solution:** Line across $\frac{1}{4}$ hp and 1140 rpm on fractional horsepower rpm scale to reference line. New line from intersection point through 1425 rpm (nearest 50-cycle speed faster than 1140 rpm) gives $\frac{1}{2}$ hp. Next lower 50-cycle speed is 950 rpm which gives power requirement between $\frac{1}{4}$ and $\frac{1}{8}$ hp.

Example 5: A blower requires 1.5 hp to drive it at 3500 rpm. How much power and torque does it take to drive it at 2900 rpm. **Solution:** 1.5 hp at 3500 rpm is normally considered as an integral horsepower rating, but a straight line across 1.5 hp and 3500 rpm on the integral horsepower rpm scale intersects the reference axis off the paper. This difficulty can be avoided by using the fractional horsepower scale and by using the 3500 rpm marking rather than the 3450 rpm marking to obtain an intersection point on the reference axis. Line is drawn from the intersection point to the 2900 rpm point, also on the fractional horsepower scale, resulting in a power requirement of 640 watts or between $\frac{3}{4}$ hp and 1 hp. (The power scale is direct reading regardless of which speed scale was used). Torque required can be read directly on torque scale as 25 oz-ft. If torque is desired in lb-ft it can be read as 15.6 and divided by 10, obtaining 1.56 lb-ft.

Other Uses

The nomogram is also useful for recording the speed-torque and speed-power characteristics of a large number of fans. At one time the author had some 40 or 50 points marked on the reference axis, labeled to indicate the fan to which each point is referred. From the single point on the alignment chart, the torque or power required by any one of the fans at any speed was very quickly obtained. This was particularly useful in determining which was the fan best suited for testing any particular motor of any given horsepower and speed rating.

EDITOR'S NOTE. Based on an unpublished paper presented at the AIEE Conference, on the Application of Motors to Space Heating and Cooling Equipment, St. Louis, Missouri, October 19, 1955. For a discussion of the effect of power factor, efficiency, speed and starting torque on performance and cost, see article "Motors for Direct-Connected Fans," on page 194 in this issue.

(continued on page 219)

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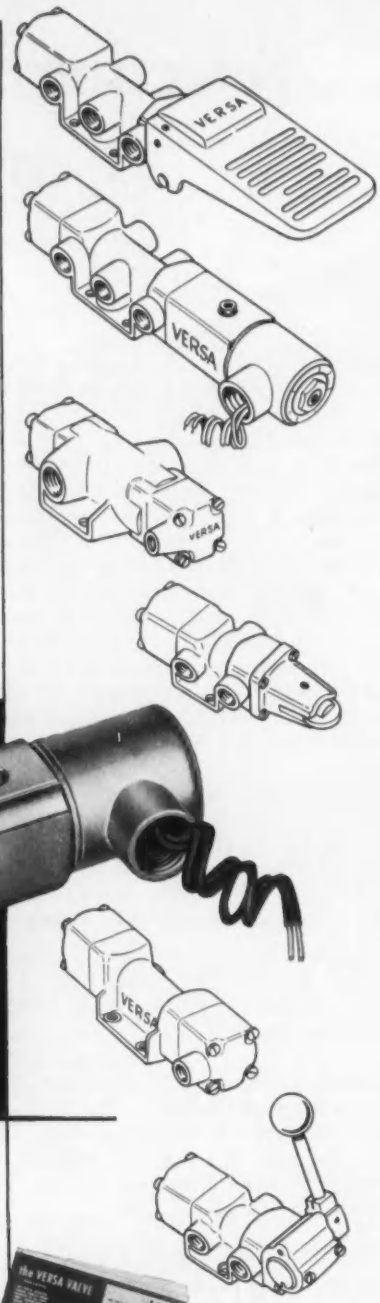

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Selecting Motors for Fans and Centrifugal Pumps *(continued from page 217)*

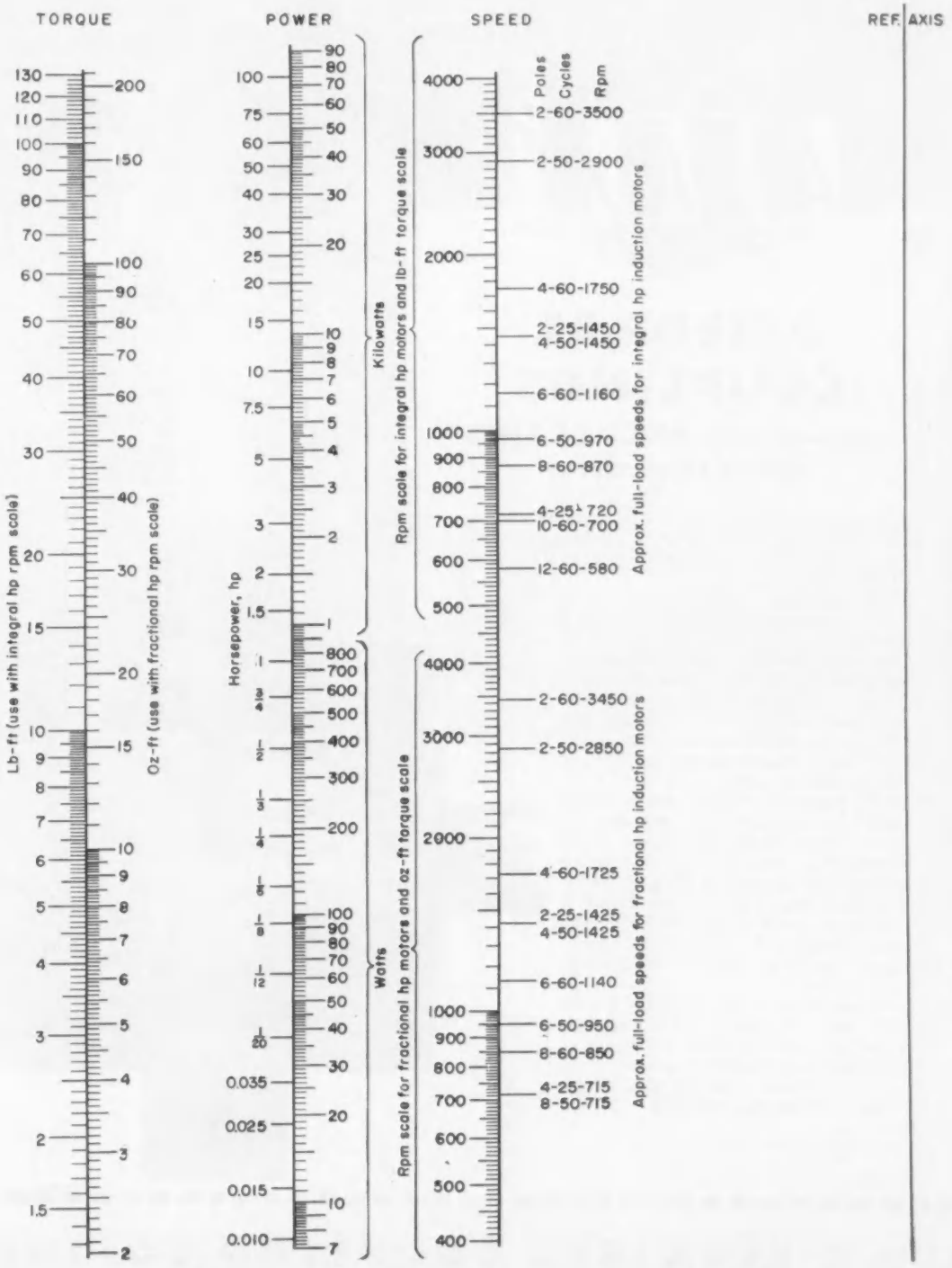

Fig. 1—Nomogram for selecting motors when torque varies with cube of speed.

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Weaving, twisting, high torque, sudden starting and stopping and heavy loads are being handled on many Alliance Cranes by Ajax Dihedral Couplings.

This is another dramatic example of how the new and greater misalignment capacity of Ajax Dihedral Couplings overcome conditions that tear the heart out of direct-connected equipment. Ajax Dihedral Couplings protect motor housings and bearings, winches and running gear under the severe strains encountered on cranes, shovels, oil drilling rigs and other difficult jobs.

Ajax patented dihedral tooth design has less clearance than conventional gear type couplings. More tooth strength is provided under misalignment than is possible with any other tooth shape. Load is distributed at center of teeth at the point of greatest strength. Johns-Manville "Clipper" Seals keep lubricant in and foreign matter out.

Design engineers are invited to get the facts on Ajax Dihedral Couplings on this basis,—if you have alignment or misalignment troubles you can't afford to be without Ajax Dihedral Couplings! Tell us your troubles.

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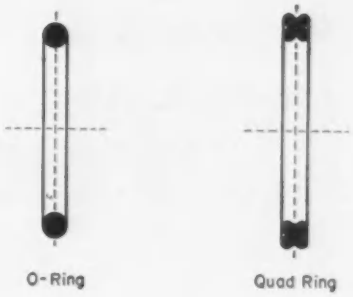
Friction Characteristics for Hydraulic Seals

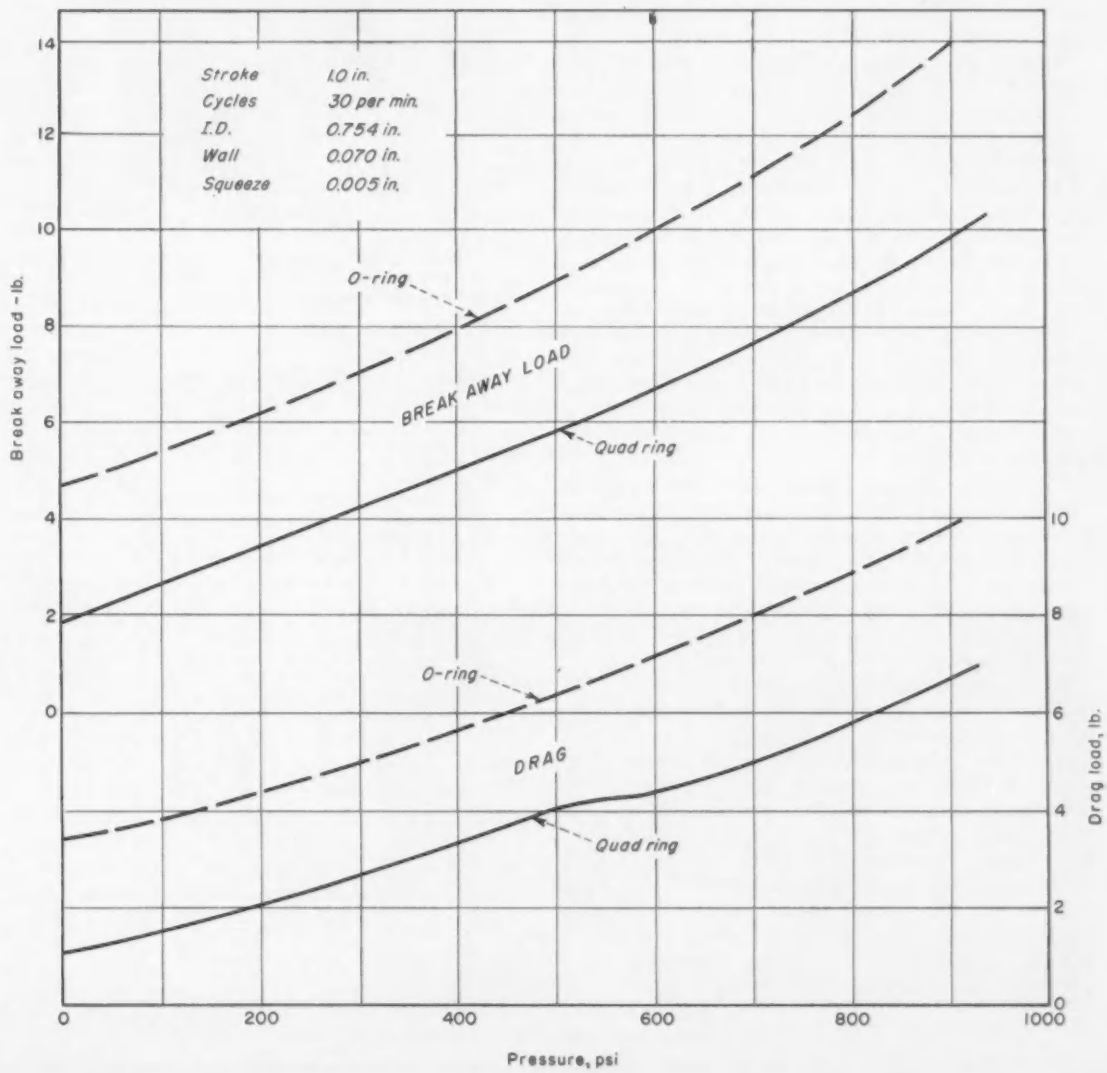
ROBERT W. CARLSON
Vice-President, Minnesota Rubber and Gasket Co.

FOUR-LIPPED SEAL, called a Quad Ring,* was developed to replace standard O-ring packings and gaskets where: (1) packings have a tendency toward spiral twist; (2) pressures are less than 8 psi; (3) pressures are too high for effective sealing with O-rings; (4) lubrication is difficult; and (5) friction must be kept to a minimum.

The curves below compare the break-away load and drag load of the two types of seals when used on a valve annulus with 75 per cent reaction area.

* Reg. U. S. Pat. Off.





Single-Stage Torque Converter for Heavy Equipment

Minimum and maximum ranges of this torque converter are, respectively, 30 hp at 1150 rpm and 198 hp at 2400 rpm. Accompanying curve shows the input hp and speed throughout the converter's entire range. Specific torque ratings are 165, 200, 240, 285 and 330 lb-ft, depending upon the impeller blading selected.

The converter's circuit differs from those of other single-stage units in that it is somewhat pear-shaped rather than round or elliptical. This type of circuit is said to permit converter fluid to leave the impeller blades at constant diameters. Design of the circuit is such that the unit has a substantial amount of natural fluid circulation for cooling, which assists in keeping size of charging pump and other parasite load losses to a minimum. Circuit members for different torque ratings are completely interchangeable.

Another distinctive feature is the unit's "unloading" arrangement. This is accomplished through blading arrangement and design rather than through conventional free-wheeling devices. At high operating speed ratios the turbine develops a counter-head which stops fluid circulation. This is believed not only to simplify construction but also to eliminate a device which could cause failure during operation.

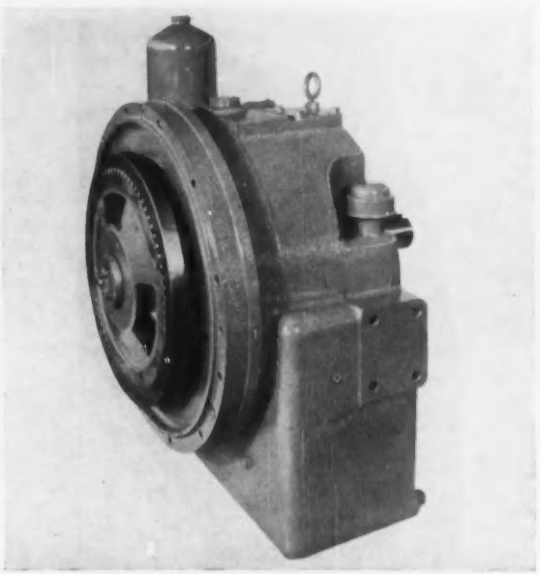
The charging pump is gear-driven from the impeller at a step-up ratio of 1.15:1 and has a capacity of 5 gpm at 1800 converter rpm. It also serves as a booster pump, augmenting natural circulation and forcing converter fluid through the heat exchanger. A tube connects the pump to the suction side of the impeller. The control valve assembly contains the pressure-regulating valve, which maintains a basic pressure of 40 psi on the converter circuit.

Recommended operating temperature range for the converter is 180 to 220 F, with 250 F the maximum permissible on a continuous basis.

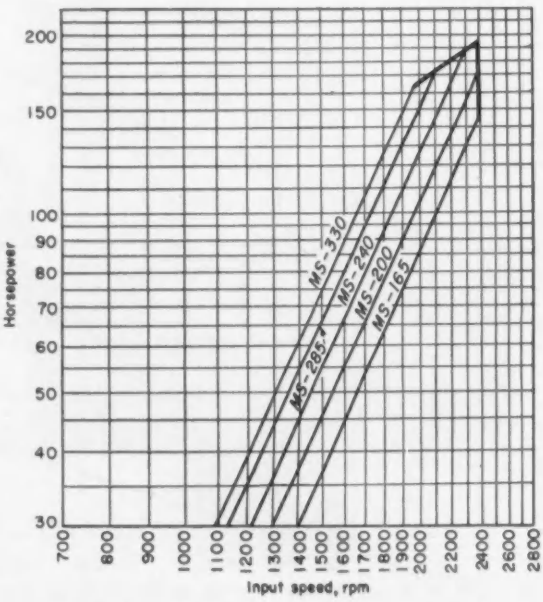
Two types of output shaft governor drives can be installed with this torque converter. One is the commonly used flexible cable to the prime mover's governor. The other arrangement utilizes a governor bolted to the converter housing. Linkage is, of course, provided by the customer or original equipment manufacturer.

Initial production includes four models: with clutch input, with spider drive input, with double-ended SAE housing, with flange input and flange output. Twin Disc Clutch Co., Racine, Wis.

For more information—
Circle 1 inside back cover



HEAVY-DUTY BALL, straight roller and tapered roller bearings are used throughout this torque converter, developed for earth-moving, railroad, materials handling and other types of equipment.



SINGLE-STAGE TORQUE converter's horsepower ratings at various speeds are shown for up to 200 hp. For similar data on higher horsepower capacities, consult manufacturer.

AND MATERIALS

SPECIFIED BY PRODUCT ENGINEERS

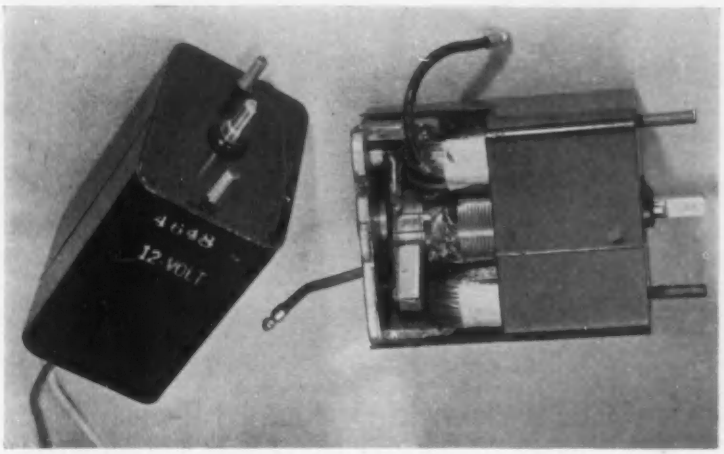
Rectangular Electric Motors - 140 in.-oz Output

Designed to give the same output as comparable round motors but in significantly less space, a line of rectangular motors has been developed. The line is available in 6, 12, 24 and 32-v ranges, with outputs up to 140 in-oz. Initial applications are expected to be in the automotive and truck industry for use in window regulators, seat adjusters, air conditioning units and other areas where space is limited.

Rectangular construction of the new motor is made possible by a new mechanical design. The field magnetic circuit has been rearranged. A special pole piece pattern is employed.

The motors are of all-welded construction with ⅛-in. thick stampings. This construction is said to provide maximum stability and resistance to twisting, eliminating armature misalignment often caused where motors with through-bolts are subject to constant vibration.

Flexibility of installation is afforded by the broad flat surfaces of the motors. Assembly bolts can be attached in any position, according to customer specification. In addition, the shaft can be extended from both ends for double load application, the motors can be made waterproof. Sintered bronze bearings at each end of the shaft eliminate oil wick reservoirs. Dimensions of the 12-v motor are 2⅛ x 3 x 3¾ in. overall. Leece-Neville Co., 1374 E. 51 St., Cleveland 3, Ohio.



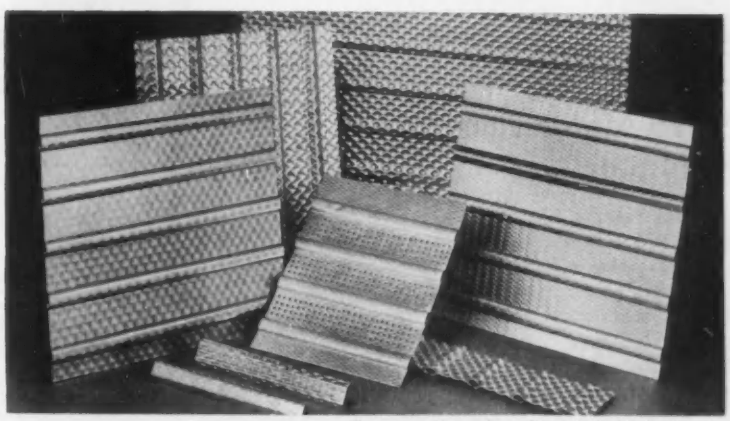
MECHANICAL ARRANGEMENT of pole piece and other components which makes possible rectangular shape can be seen in cutaway unit.

For more information—
Circle 2, inside back cover

Rigidized Tube-In-Strip

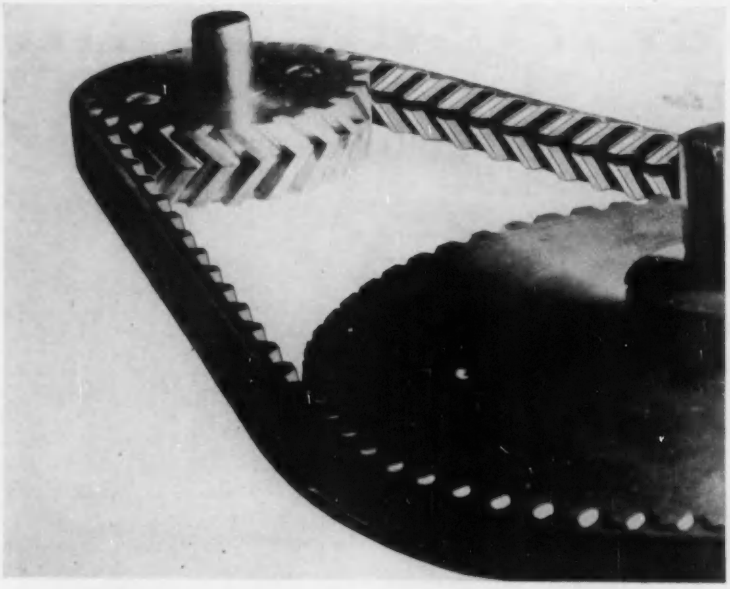
Tube-in-strip is a single sheet of solid copper, brass or aluminum in which tubes are inflated in running lengths in a variety of shapes and sizes. By pattern-rolling the flat sheets or strips before inflating, any of the more than 40 standard patterns can be produced. The strips are then inflated by the application of air or hydraulic pressure to form the tubes.

The rigidizing is said to increase rigidity as much as 108 per cent, buckling strength up to 70 per cent and produces 92 per cent greater tensile strength than the original flat metal. Rigidized Metals Corp., 673 Ohio St., Buffalo 3, N. Y.



For more information—Circle 3, inside back cover

CONTINUED ON PAGE 224



Drive Belt With V-Shaped Tread

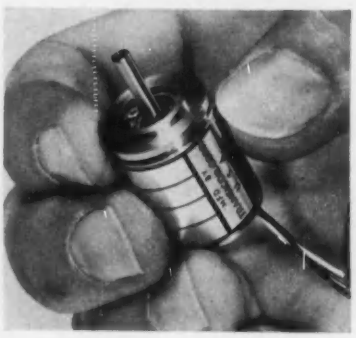
A non-slipping belt which is said to permit greater accuracy in transmission or rotational motion is designed to be used with pulleys or gears having teeth cut in a herringbone pattern. The belt's cleats are formed so that they index with the V-shaped teeth. The belt will transmit rotational motion over the same ratios normally encountered in gear drives. This accuracy results from the fact that the special neoprene of which the belt is constructed provides a pre-determined resiliency of the belt teeth. Tooth error of the gear is integrated over all teeth engaged.

The V-shaped tread of the belt tends to continuously wedge and center the belt in the corresponding teeth of the gears with which the belt engages. This allows the associated gears to be constructed without belt restraining rims. This wedging action takes place continuously, due to the overlapping helix angle.

At present, only one size belt is being made, $\frac{3}{8}$ x 15 in. for load up to 16 in.-oz. Among the applications expected for the belt are recording equipment and other types of precision synchronism drives. Kinevox Div., Electromation Co., Burbank, Calif.

For more information—
Circle 4, inside back cover

Servo Motor and M-G Set



A servo motor identified as Type 8-M is said to have exhibited the characteristics below after being energized (fixed phase) for 1 hr at 25 C, in still air. Volts per phase was 26.0 v, free speed, 6700 rpm. Stall torque was 0.20 in-oz, with a temperature rise of 51 C after a full-power stall. Output measured 0.293 w and current 0.092 amp. Dimensions are $\frac{11}{16}$ x $\frac{3}{4}$ in. dia.

The characteristics of the servo motor-generator were generally the same as the values given above for the motor. Transicoil Corp., Worchester, Montgomery County, Pa.

For more information—
Circle 5, inside back cover

Automatic Recording Tape Cartridges

This device is composed of a plastic cartridge and a continuous-loop type of recording tape in lengths even beyond 1200 ft (depending on model of cartridge used). The message or

data is recorded on the tape after being rolled up on the cartridge spool. The casing is then assembled.

The unit can then be inserted, played and removed from specially designed playing-recording equipment as often as desired without any threading being required or ever touching the tape again. Cousino, Inc., 2325 Madison Ave., Toledo 2, Ohio.

For more information—
Circle 6, inside back cover

Automatic V-Belt Clutch

This clutch is for gasoline engine and electric motor applications up to 2 hp. It is said to take advantage of belt pull to increase clutch capacity and to provide a speed differential between engagement and release. The clutch utilizes the V-belt as the fric-

CONTINUED ON PAGE 226

Using

DU PONT ELASTOMERS

NEOPRENE • HYPALON®

in Design

HYPALON® can be compounded in an unlimited range of weather-resistant colors

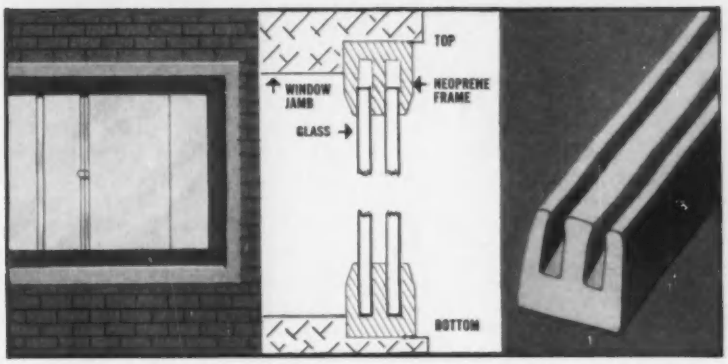
HYPALON, Du Pont's new synthetic rubber, brings brilliant color to the design field as well as superior performance for rubber materials. Since HYPALON does not require carbon black as a reinforcing agent, a complete range of stable, weather-resistant colors is possible. Colored compounds of HYPALON start bright . . . *stay* bright despite severe exposure conditions.

TWO YEARS of outdoor exposure with virtually no trace of color failure, thanks to the superior color stability of HYPALON.

In addition to outstanding color stability, HYPALON has many other advantages that can help your products give *extra-long service* on industry's toughest jobs. Compared to other kinds of rubber, HYPALON shows unusual resistance to hardening at elevated temperatures (250°-350°F.). It is completely resistant to ozone and has exceptional resistance to strong oxidizing agents such as chromic acid.

When your design calls for a resilient material that must have extra-high resistance to ozone, heat and chemicals, it will pay you to take a close look at HYPALON. For more information, just mail coupon.

Resilient NEOPRENE window frame cuts installation and maintenance costs



NEOPRENE CHANNEL STRIP makes this window air- and water-tight, easy to install.

The Silent Glide Corp. of New Jersey has reported the development of a new sliding-window design using a resilient neoprene frame that can be installed by semi-skilled labor and requires no maintenance. Over 5,000 such installations have been made in housing developments to date.

The window consists of two plate-glass panes sliding in extruded channels made of light-gray neoprene synthetic-rubber composition. The slotted strips are cut from continuous lengths of neoprene extrusions to fit various size windows, mitered, then cemented and stapled in place. The glass panes are ground and polished and installed by inserting them into the top of the frame and dropping them into the grooves in the lower strip.

The resilient neoprene strips seal the glass, yet allow the panes to slide easily. Neoprene requires no protective paint or chemical coating, because it resists weather and sunlight attack as well as acid fumes encountered in industrial areas. It will not warp, chip, crack, soften or harden. The manufacturer gives this explanation of his use of neoprene: "Our window frames must be good for the life of the building. That's why we're using neoprene. We've seen neoprene parts functioning perfectly after being in service outdoors for over 15 years."

Perhaps your product design can benefit from an evaluation of the properties of neoprene. We'd be glad to send you further information. Just fill in and mail the coupon below.

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Elastomers Division, Dept. PE-5
Wilmington 98, Delaware

Name _____ **Position** _____

Firm _____

Address _____

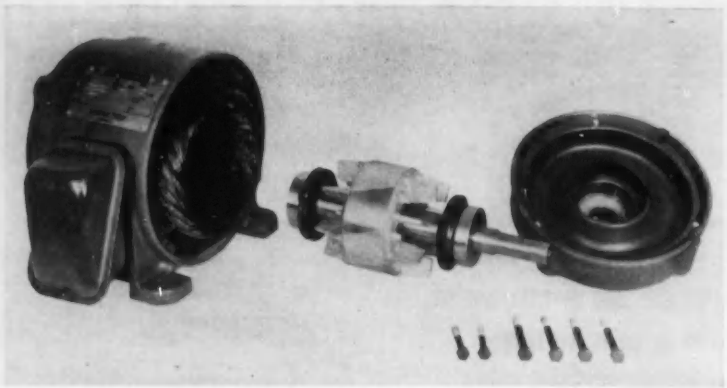
City _____ **State** _____

tion element and employs a mechanical action to multiply the forces into greater gripping power against the V-belt and to "lock" the clutch in engagement.

The disengaging speed of the clutch is considerably lower than the engaging speed, permitting high speed starting at maximum torque with full torque at reduced speed. Speed spreads up to 1000 rpm are available. Chatter is eliminated by an interlock which prevents independent action of the centrifugal elements.

The clutch weighs 12 oz. The unit has a pulley diameter of 2¾ in. and is available in ½, ⅝, and ¾-in. bore. Rev-O-Loc Clutch Corp., P. O. Box 1806, Milwaukee 1, Wis.

For more information—
Circle 7, inside back cover



Synchronous Induction Motor ¼ to 40 hp

A synchronous motor for general industrial use is available in ratings from ¼ to 40 hp. It is built on standard induction motor frames and enclosures, and uses a simple die-cast rotor. The motor is said to require no brushes, slip rings or windings on the rotor, separate source of direct current excitation, or special starting equipment, as is the case with standard synchronous motors.

The new drive starts as an induction motor with a very high locked-rotor torque, accelerates and pulls into synchronism quickly, and runs as a synchronous motor. Having a high (175 to 200 per cent) pull-out torque, the motor remains in synchronism regardless of load or line voltage fluctuations. The motor has been designed to operate over a wide frequency, and therefore, a wide speed range. Frequencies of 300 cps and speeds above 10,000 rpm are available. Motors for frequencies as low as 10 cps have been developed.

Applications where these motors are installed or are under consideration include high-speed meat slicing, drives for military electronic power supplies, packaging machinery, printing presses, sheet glass conveyors, wire drawing, and stable frequency converter sets.

The motors need only standard across-the-line starting equipment, except in the very largest ratings, where reduced voltage starters are required.

For applications where operation of several motors must be synchronized over a range of speed, an electromechanical drive to supply variable frequency for these motors has been developed. Allis-Chalmers Mfg. Co., Milwaukee 1, Wis.

For more information—
Circle 8, inside back cover

Plug-in Static Switching Units

These components are modular plug-in cartridges roughly 3 x 2 x 2 in. deep. Encapsulated in polyester resin and fitted with terminals on the upper and lower faces, the modules plug into a specially designed power channel. When more than 15 modules are required for a system, additional channels can be mounted side-by-side or end-to-end. Singly or mounted, the encapsulated units are capable of withstanding mechanical shock and adverse environments.

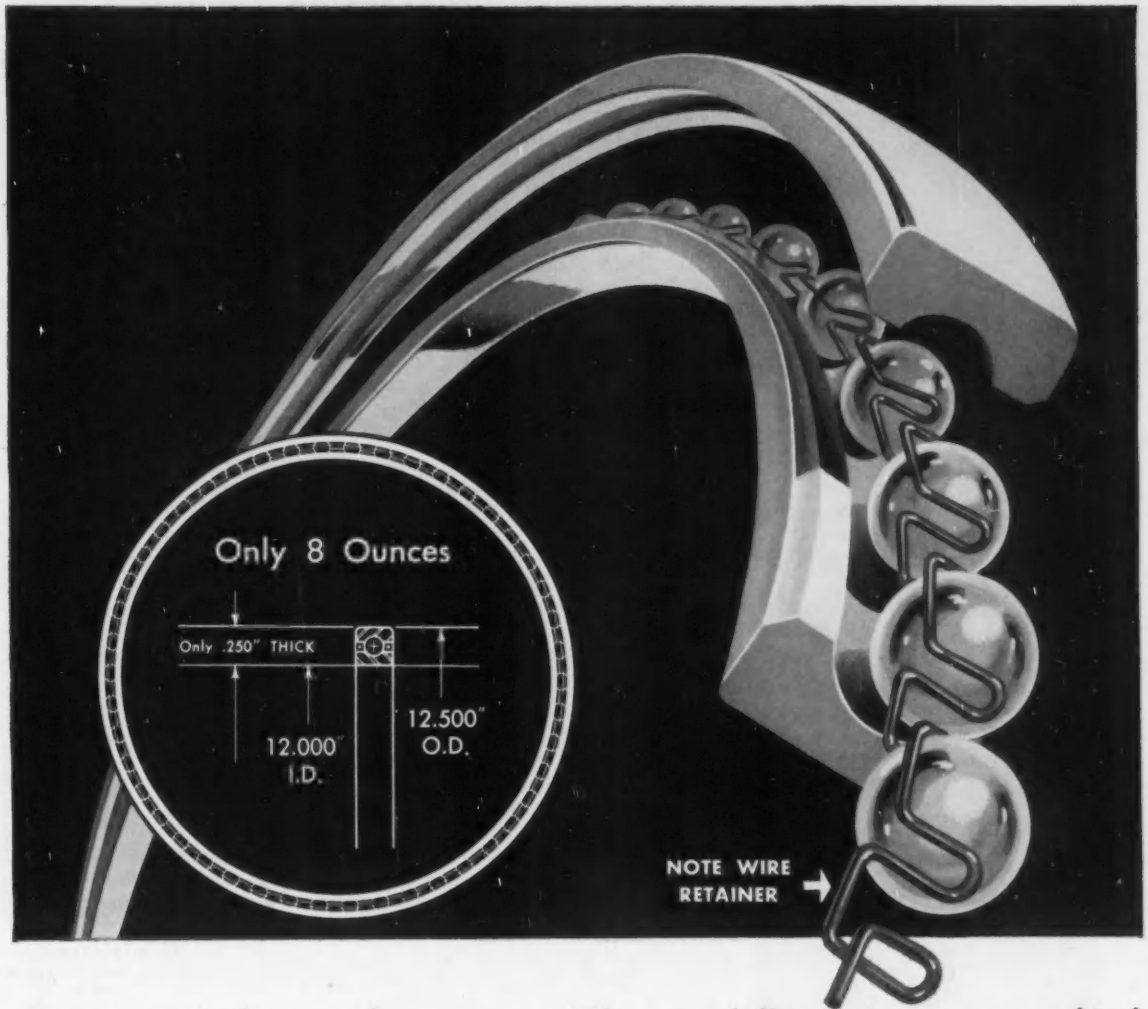
Simplicity for assembly and maintenance is furthered by numeral identification of each terminal and by a logic diagram printed directly on the module. Phasing the module has been made simple: an external color dot indicates how the unit should be positioned. To reverse its phase relationship it is only necessary to remove the module, reverse it, and plug it in again. Westinghouse Electric Corp., 401 Liberty Ave., Box 2278, Pittsburgh 30, Pa.

For more information—
Circle 9, inside back cover

Recording Tape Cartridge Threads Itself

A long-play tape cartridge, the first to play a full hour at 7½ ips is slightly larger than standard 1200-ft reels. Half-hour and 15-min size cartridges

CONTINUED ON PAGE 228



Save weight and space with world's thinnest radial ball bearings—*Reali-Slim* by Kaydon

HERE it is! A *Reali-Slim* radial ball bearing with a wire separator that has just short of a full complement of balls for maximum capacity. What's more, you still get all the advantages of a separator between the balls. This design also gives you a bearing that's light-in-weight and is, without a question, the thinnest bearing ever built in this diameter.

Whatever your product design, there's a small or large diameter *Reali-Slim* bearing that can be the right answer to your thin-section bearing problems.

The radial ball bearing, illustrated here, is *really slim* — 12.000″ I.D., 12.500″ O.D., .250″ thick . . . *and weighs only eight ounces.* It has 9,810 lbs. static load capacity, 1,256 lbs. at 100 rpm. Kaydon is able to produce *Reali-Slim*, high-precision bearings because Kaydon specializes in the unusual.

Kaydon bearing engineers are prepared to give you valuable help with technical, thin-section bearing problems.

For detailed information on Kaydon's *Reali-Slim* line, ask for engineering catalog No. 54-RS3 detailing:

Reali-Slim Ball Bearings — Conrad, angular contact and 4-point contact types in seven standard cross sections from ¼″ to 1.000″ and in bore diameters from 4″ to 40″.

Reali-Slim Roller Bearings — Radial and taper roller types in cross sections from 9/16″ and in bore diameters from 5″ to 40″.

THE KAYDON ENGINEERING CORP.

MUSKEGON • MICHIGAN

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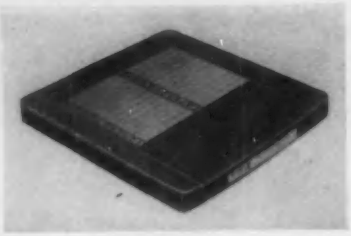
All types of ball and roller bearings — 4″ bore to 120″ outside diameter . . .

Taper Roller • Roller Thrust • Roller Radial • Bi-Angular Roller • Spherical Roller • Ball Radial • Ball Thrust Bearings



are similarly comparable to standard 600- and 300-ft reels.

Using standard ¼ in. tape and a continuous loop, tape tension is said to be constant at all times, resulting in more stable reproduction.

The design of the cartridge minimizes exposure of tape to dust and dirt. Also, static charges which normally attract dust are neutralized. The plastic cartridge is inserted in the playing device and automatically locked in proper position. The tape itself is never touched or handled so that nicks and wrinkles are avoided. Sound Electronics Laboratories, Div. of G. H. Poulsen & Co., Toledo, Ohio.

For more information—
Circle 10, inside back cover

Fold-Away Drafting Board Fits Into Desk Drawer

This unit consists of a complete drawer, drawing board and parallel rule. It was primarily designed to go with the manufacturer's line of office furniture components, but can be bolted or screwed to any conventional desk or table top.

When folded away, the drawing board is completely out of sight and the whole unit appears as a conventional center drawer, leaving the desk or table top completely clear for regular paper work. Self-contained suspension fixtures equipped with nylon roller tracks assure smooth gliding of the drawer. The drawing board itself, attached to the drawer by specially-designed hinges, moves easily into position on the desk top at a comfortable working slope.

The board, complete with parallel rule attachment, comes in two sizes. The smaller unit has a 24 x 24 in. drawer equipped with a 20 x 15 in. board; the larger one, a 30 x 30 in. drawer with a 26 x 21 in. board. Arnot-Jamestown Div., Aetna Steel Products Corp., 730 Fifth Ave., New York, N. Y.

For more information—
Circle 11, inside back cover

Battery with "Solid State" Electrolyte

This battery is described as having no water whatsoever in its make-up. Voltage is generated by the differential in contact potential between two conductors in contact with a solid electrolyte. It is said to undergo only negligible chemical reaction when idle. On the basis of current tests, shelf life of 10 yr or more can be expected.

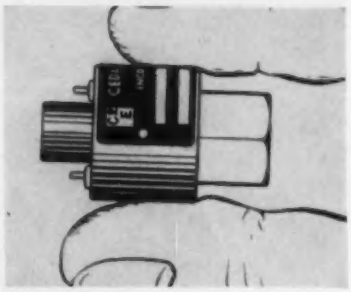
A unit to provide 200 v can be contained in 1 cu in. of volume. The battery holds stable output voltage over a temperature range from −65 F to 165 F. Efficiency does not drop even at the low limit of this temperature range. Present current capacities fall in the micro-amp range. Work is progressing on techniques to provide higher current ratings. Indicated applications include high voltage calibration equipment, ionization chambers, geiger counters and as high voltage bias cells in electronic equipment operating at elevated ambient temperatures. P. R. Mallory & Co. Inc., N. Tarrytown, N. Y.

For more information—
Circle 12, inside back cover

Adjustable Flow Regulator

This flow regulator is designed for panel mounting. It is for any system requiring a variable adjustment of the flow rate over a wide operating range. It has an aluminum body with internal parts of hardened steel and an adjustable control handle for either right or left rotation. Four models cover a range of 0.5 to 20 gpm, 3000 psi operating pressure. Dimensions are 4x4x9⅛ in. depth; weight, 6¼ lb. Waterman Engineering Co., 725 Custer Ave., Evanston, Ill.

For more information—
Circle 13, inside back cover



Miniature Straight-Through Solenoid Valve

The valve is available in a variety of fittings, normally opened or normally closed, for continuous duty on either ac or dc. Rating is 2.2 w, 30 psi or 30 in. hg. Cedar Engineering, Inc., 5806 W. 36 St., Minneapolis 16, Minn.

For more information—
Circle 14, inside back cover

Silicon Power Rectifiers

These new silicon rectifiers are reported to be capable of operating with extremely high reverse voltages and accompanying low reverse currents. Together with a very low forward voltage drop the rectifier delivers large power to the load with relatively little dissipation. The unit is capable of operating in ambient temperatures up to 125 C.

These rectifiers are available in three different configurations depending on the heat dissipation required. The smallest unit is capable of handling ¼ amp without benefit of an additional heat radiator, and features pigtail construction. The second type features screw-type mounting in a small cylindrical package and is capable of carrying 1 amp. The third has

CONTINUED ON PAGE 230

The Engineer from Continental Screw Co. ...

...makes Phillips "Bits-Holders-Screws" for you—another exclusive from Continental

This 3-way fastening combination makes power-driving practical

Manufacturers have cut fastening costs up to 50% by switching to Continental's Phillips "Bits-Holders-Screws." This 3-way fastening combination, exclusive with Continental, makes power driving really practical—even on your finished parts.

Did you know, for example, that just one size Phillips Driver will drive 85% of all Phillips Screws used in industry? And just four sizes of Phillips Drivers will fit the entire range of screw sizes?

Remember, no other company makes Phillips "Bits-Holders-Screws." And Continental offers you a complete selection of other Phillips fasteners, too. Talk to the engineers at Continental about the money you can save with power driving. Call them today.

Free Booklet: Continental Screw Co. offers you a free booklet on Hy-Pro Phillips Insert Bits and Holders. Just send your name and address to Continental Screw Co., New Bedford, Mass.

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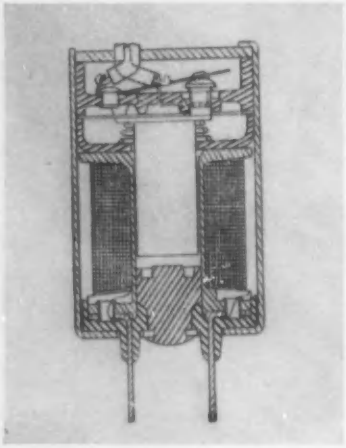
New Bedford, Massachusetts, U.S.A.

a hexagon base screw-stud mounting and is capable of handling 1¼ amp. CBS Hytron, Div. Columbia Broadcasting System, Inc., Danvers, Mass.

For more information—
Circle 15, inside back cover



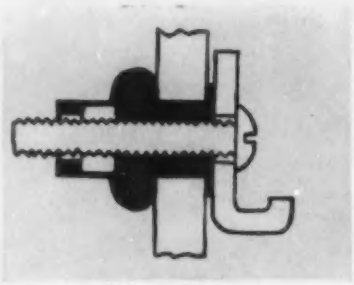
Switching Device Combines Relay and Solenoid Functions

Unit is totally enclosed in a metal case with molded bakelite at the contact end to protect against moisture, dust and impact. Three contact leads are equipped with AMP or Douglas-type terminals; coil has two AMP terminals. These switches are available for any voltage from 6 to 115 v, non-inductive. Standard contact combination is single-pole, double-break. Unit is 2$\frac{13}{32}$ x 1$\frac{7}{32}$ x 1$\frac{5}{32}$ in. Guardian Electric Mfg. Co., 1621 W. Walnut St., Chicago 12, Ill.

For more information—
Circle 16, inside back cover

Anti-Vibration Fastener

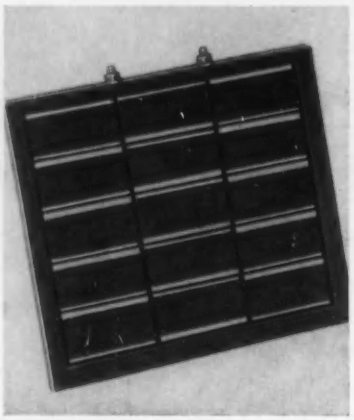
This fastener is a tough rubber bushing, in one end of which is bonded a threaded hex brass nut, the opposite end being provided with a flange. These nuts will give an air-tight and watertight seal and will hold where panels are too thin to be tapped to take a screw. They are ideal for making attachments to porcelain, thin plastics, glass, laminated wood, sheet



metal, insulation board or any composition material for which normal methods are unsuitable.

These nuts can be assembled from one side as it is not necessary to have rear access. They come in a range of diameters from $\frac{5}{16}$ to $\frac{1}{2}$ in., thread sizes 6/32, 10/32, $\frac{1}{4}$-20. Rockwell Products Corp., 146 Central Ave., Newark 3, N. J.

For more information—
Circle 17, inside back cover

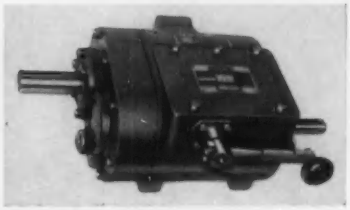


Photosensitive Selenium Elements

This is a converter of solar energy into electrical power and is designed as a power supply for transistorized devices, such as portable radio receivers and transmitters. These devices may also be used in conjunction with miniature storage batteries to supply continuous power to a load. These products are currently available in production quantities.

The unit, consisting of a number of selenium photosensitive elements connected in series, can supply electrical power in the milliwatt range when exposed to sunlight or artificial light. When the sun battery is exposed to very bright incident sunlight, approximately 10,000 ft-c illumination, it can supply a maximum output power of 5 mw per active square inch at an output voltage of 0.26 v per sensitive element. International Rectifier Corp., 1521 E. Grand Ave., El Segundo, Calif.

For more information—
Circle 18, inside back cover



Forward and Reverse Transmission

A forward and reverse transmission, with clutch control, has maximum reduction up to 3:1. Torque capacity is 865 lb-in. All gears and shafts are of alloy steel, heat-treated and gear teeth are shaved. Weight is approximately 120 lb. Western Mfg. Co., 3400 Scotten Ave., Detriot 10, Mich.

For more information—
Circle 19, inside back cover

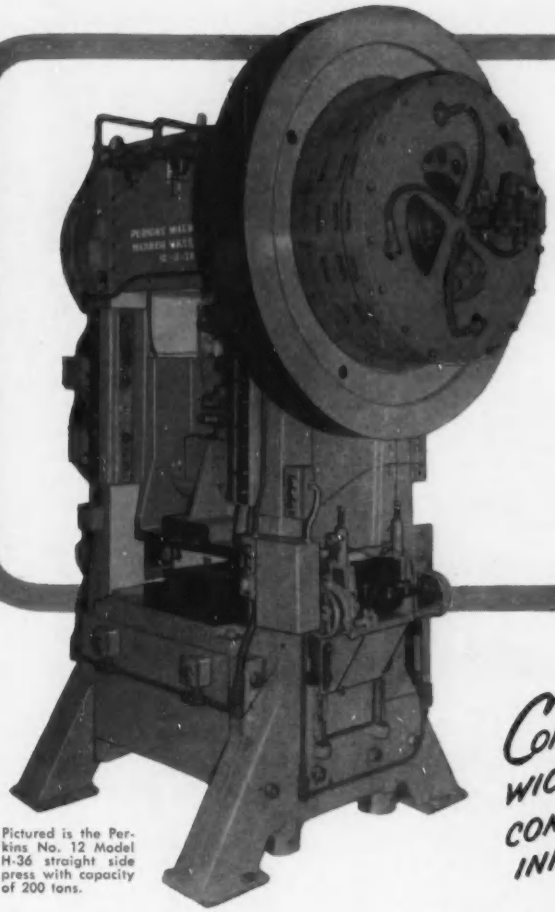
Designed for high-speed automatic control applications, these two-way air valves are used for such purposes as automatically ejecting stampings from punch presses and kick presses, for providing an automatic air blast for removing chips, dust and shavings in drill press, plastic molding, cold-heading and machining operations. They operate direct from any compressed air line, without requiring the use of a filter, to produce a powerful, automatic air blast which can be accurately timed as a part of the work cycle by actuating the valve trigger with any suitable cam or tripping device.

The valve is constructed of solid

CONTINUED ON PAGE 232

WICHITA Air-Tube CLUTCHES The Best Choice . . .

"AFTER INVESTIGATION WE SELECTED WICHITA"



Pictured is the Perkins No. 12 Model H-36 straight side press with capacity of 200 tons.

—Perkins Machine Company
Warren, Mass.

Perkins Machine Company investigated the clutches of several manufacturers and came to the conclusion that WICHITA had the best design as to simplicity of maintenance and efficiency of operation. Maintenance experienced on other types has been eliminated. Presses operate at higher speed ranges. Safety is increased.

Thousands of WICHITA installations the world over prove these great advantages.

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MORE WICHITA CLUTCH FEATURES

- **Soft, Smooth Engagement and Disengagement**
- **Simple Design**
- **Efficiency Engineered**
- **Positively Ventilated for Cooler Operation**
- **Extremely Long Life**
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Smith-Keser & Co. (Main Office), Avon, Conn.
Smith-Keser & Co., Philadelphia 44, Pa.
Smith-Keser & Co., New York, N. Y.
Frank W. Yarline Co., Chicago, Ill.
Power Rig & Equipment Co., Inc., Long Beach, Calif.
Sales Engineering Company, Inc., Salt Lake City 4, Utah

Robert R. King Co., Cleveland, Ohio
John C. Burge, Oklahoma City, Okla.
Dominion Power Press Equipment Ltd., Longacres P. O., Aldershot, Ontario, Canada
Hunt Tool Co., Houston, Texas
Industrial Air Controls Co., Fort Worth, Texas
Allied Transmission Equipment Co., Kansas City 8, Missouri

WICHITA Clutch COMPANY, INC.
WICHITA FALLS, TEXAS, U.S.A.

cast brass with hardened steel parts and is flat and square on both sides to make it easy to install on any machine surface or to assemble several valves in a row for multiple air blasts. The inlet port has a ½ in. and the outlet port a ¼ in. pipe size female thread. W. I. Martin & Co., 224 S. Michigan Ave., Chicago 4, Ill.

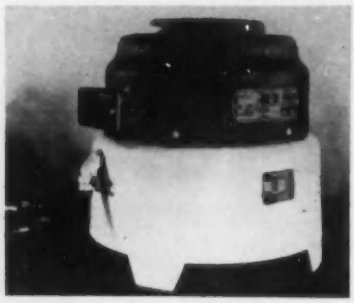
For more information—
Circle 20, inside back cover

Hand Pump Pressure Oiling System

This unit delivers oil, under pressure, to various points of all types of equipment such as line shafts, gears, chains, cams, gibs, power cone spindles, round or flat stock, felt pads. A pressure pump is built into the 4 oz shatterproof reservoir. Oil supply is always visible.

A six-outlet distributor is connected to the reservoir assembly. Plastic, transparent and flexible tubing is attached to the distributor outlets and run to the bearing points, which can be as much as 100 ft away, in any direction. A small amount of oil is fed to all bearings simultaneously each time the pump is stroked. All feed tubes remain filled, ready for the next cycle. Trico Fuse Mfg. Co., 2948 N. 5 St., Milwaukee 12, Wis.

For more information—
Circle 21, inside back cover



Converts 60 to 360 Cps.

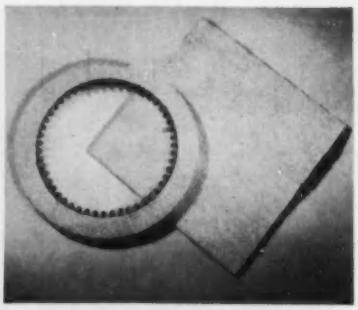
The unit consists of a 360 cps generator, direct coupled to a 60-cps, three-phase motor. Power delivered is 5 kva, 220 v, three-phase, 360 cps. Converter is 18x18 in. high; weight, 210 lb. Useful as portable or emergency source of power for high frequency tools or laboratory bench. Georator Corp., Manassas, Va.

For more information—
Circle 22, inside back cover

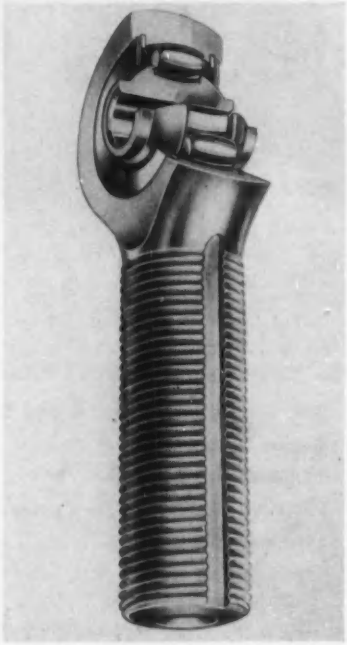
Woven Asbestos Friction Material

For oil-cooled power transmission equipment such as clutches, torque converters, power take-offs, steering clutches and brakes, this material contains no metallic particles or wires. Although all materials in this series are designed for oil-cooled service, flexibility to meet specific applications can be achieved by varying the weave, the impregnating ingredients and the processing treatment.

The new material is designed to be bonded to metal plates with thermosetting resins and assembled in oil-cooled units alternately with metal pressure plates. The thickness of the new material ranges from a minimum of 0.030 to a maximum of 0.090 in., in increments of 0.010 in. One-piece, full ring diameters are available up to 12 in. OD. Thermoid Co., Trenton, N. J.



For more information—
Circle 23, inside back cover



Rod End Bearings

This line comes in five sizes with every member of the series designed so that bearing capacity, shank strength and bolt strength are in balance. Within the family are both

CONTINUED ON PAGE 234

CUT

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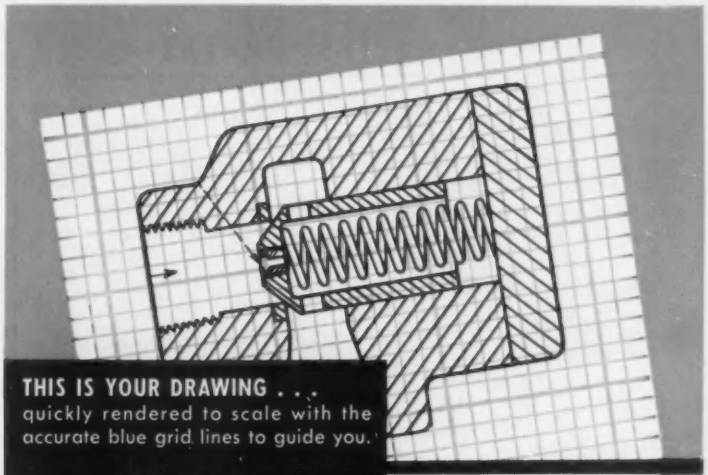

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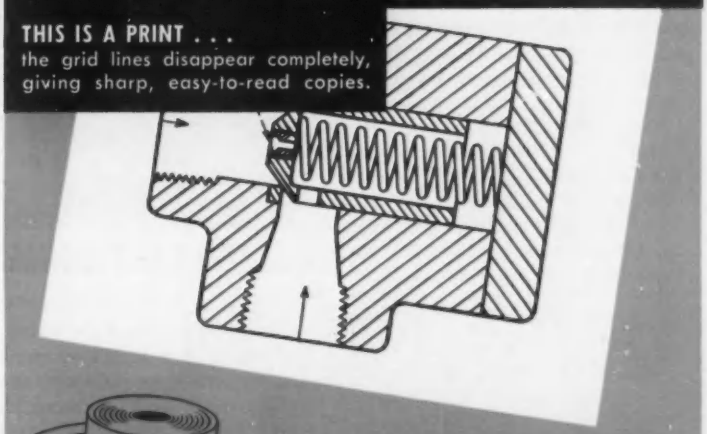

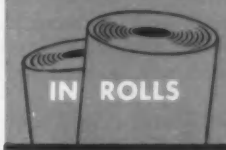

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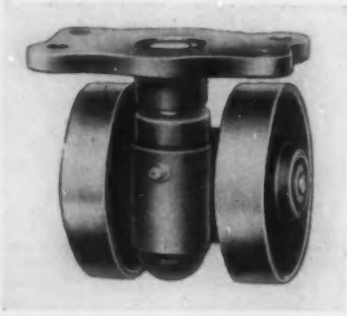
ball and roller bearing rod ends with male threaded shanks. The two ball bearing rod ends with high-strength shanks are designed primarily for manually operated control systems. Completing the series are three high capacity roller bearing rod ends for power-operated flight control systems. Fafnir Bearing Co., New Britain, Conn.

For more information—
Circle 24, inside back cover

Self-Locking Insert

Designed for use in materials such as aluminum and magnesium alloys and plastics, where a strong internal thread is required, the insert is currently being manufactured to receive and lock a 4-40 screw. It is made of non-magnetic stainless steel, for applications involving temperatures up to 550 F. It consists of two parts, which are easily installed in a drilled and tapped hole with an ordinary screwdriver. Newton Insert Co, 1321 E. 17 St., Los Angeles 21, Calif.

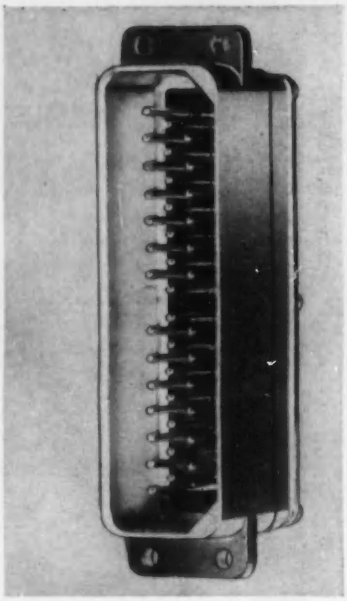
For more information—
Circle 25, inside back cover



Knee-Action, Double-Wheel Caster

A pressure-type fitting, located in the central housing, provides one-shot lubrication, to the swivel assembly and both wheels. The casters are available with all-metal wheels, or with rubber tires. Wheel diameters range from 3 to 9 in., capacity ratings from 400 to 1200 lb per caster. Hamilton Caster & Mfg. Co., 1700 Dixie Highway, Hamilton, Ohio.

For more information—
Circle 26, inside back cover



Rack and Panel Connector

This connector's forty 10-amp solder pot contacts for No. 16 stranded wire are placed in a melamine insulator. The shell has an overall length of only 3 11/16 in. and is made of diecast aluminum. Positive polarization has been accomplished with a keystone case design.

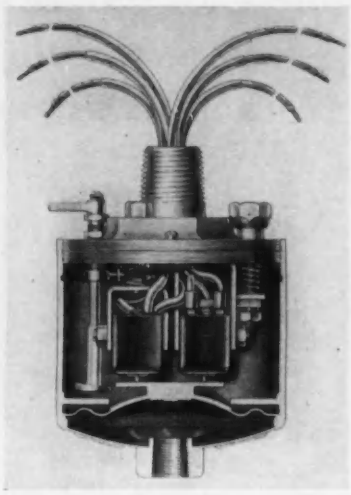
Flashover is rated at 1700 v, 60 cps, ac, rms at sea level. The weight of the mated connector is 0.381 lb. Cannon Electric Co., 3209 Humboldt St., Los Angeles 31, Calif.

For more information—
Circle 27, inside back cover

Two Pressure Switches In One

May be used to signal when pressure rises or falls to danger zone, and then to shut down the system if pressure continues to rise or fall to a predetermined safety limit. The manual reset is so arranged that the system cannot be reactivated until the pressure has been returned to a safe level.

Each switching element in the unit can be electrically independent of the other (one ac, the other dc, if necessary), or two external leads can be supplied to control a single circuit



between maximum and minimum pressures.

This pressure switch comes in three classes of proof pressures: 6, 30 and 120 psi, with an adjustable range from 0.05 to 100 psi. Barksdale Valves, 5125 Alcoa ave., Los Angeles 58, Calif.

For more information—
Circle 28, inside back cover

Copper-Clad Laminates for Printed Circuitry

Using a special bonding technique, this manufacturer reports success in cladding a non-adherent polymer (fluorocarbon plastic) with copper. It is said to be unaffected by acids, alkalies or common organic solvents. International Resistance Co., 401 N. Broad St., Philadelphia 8, Pa.

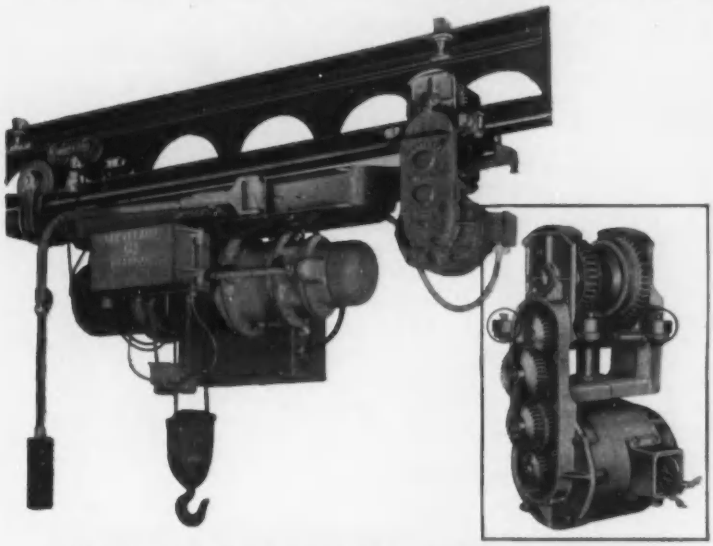
For more information—
Circle 29, inside back cover

Fixed Setting Thermostat

The unit is being offered for use on electric clothes dryers, fan and high limit switches, central heating equipment, air conditioners, ventilators. The operation is effected by a calibrated snap-action disc which completely eliminates the need for overcenter toggles, mechanisms, magnets. Contacts and disc are enclosed to provide protection from dirt, lint, dust, or exposed for faster thermal re-

CONTINUED ON PAGE 236

BEARING TIPS by McGill



CLEVELAND TRAMRAIL GUIDES MOTOR HEADS ON McGILL CAMROL BEARINGS

Motor-driven electric hoist carriers made by the Cleveland Tramrail Division of The Cleveland Crane & Engineering Company, incorporate McGill CAMROL Cam Follower bearings as side guide rollers for the motor head.

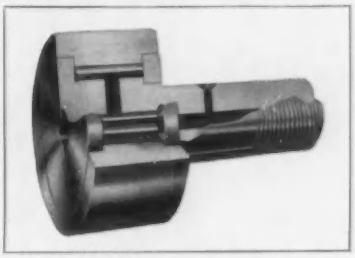
The CF bearings keep the motor head square on the monorail track used in this system and guide the head around curves. Moving on the rails at speeds up to 250 feet per minute, the bearings take the thrust load when entering into a curve.

Replacing spring loaded friction type bolt and roller units, the simplicity of mounting and the friction-free operation of the CAMROL cam followers provide dependable, trouble-free operation of the carrier assembly. Used almost six years, bearing performance has been most satisfactory.

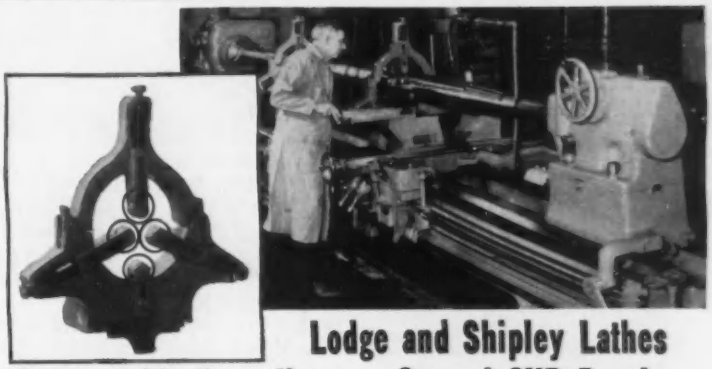
Fact-packed Bearing Catalog

Write for your copy of Catalog No. 52, a revised 140-page Bearing Selection Guide. It contains vital product information and 30 pages of engineering data.

CAMROL BEARINGS DIRECT ACCURATE CAM ACTION



Precision built throughout, CAMROL CF Bearings are designed to add the advantages of smooth accurate cam action to rugged shock-absorbing dependability in any type cam follower application. An interchangeable sealed SCF series protects critical installations.



Lodge and Shipley Lathes Support 18′ Propellors on Camrol CYR Bearings

Eighteen foot propeller shafts and other large work are supported and guided accurately on Lodge and Shipley Lathes through use of Camrol CYR Bearings. The Lodge and Shipley Company has standardized on these heavy duty Cam Yoke Roller Bearings for the Roller Jaw Steady Rest on their larger Engine Lathes. Four CYR bearings are mounted in a yoke at the ends of adjustable slides to provide dependable, precision support for a variety of work.

CAMROL CYR Series Adapts To Yoke Mounting

Internal construction of the CYR Series bearing is similar to that of a CF Series bearing with a heavy outer ring selection to withstand shock load. However, the stud is replaced by an inner ring for receiving shaft in a yoke mounting.

Insure performance with McGILL®

MULTIROL® GUIDEROL® CAMROL®
Full Type Roller Bearings

McGILL MANUFACTURING COMPANY, INC., 201 N. LAFAYETTE ST., VALPARAISO, INDIANA

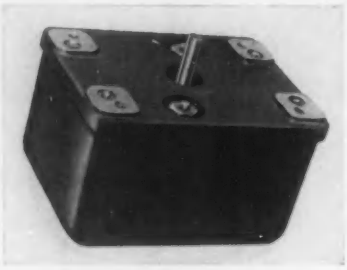
sponse where necessary. Temperature settings range from −10 F to as high as 350 F. The unit can be mounted in any position. Electrical ratings: ½ hp or 25 amp, non-inductive load at 120 v, ac; ½ hp or 25 amp, non-inductive load at 250 v, ac; 125 va. All are ratings for 100,000 cycles. Metals & Controls Corp., Attleboro, Mass.

For more information—
Circle 30, inside back cover

Axial Blower

The blower body is 2.2 in. dia and produces 60 cu ft of air per min. Motronics Corp., 241 Concord St., Glendale, Calif.

For more information—
Circle 31, inside back cover



A-c Rotary Solenoid

This series operates on standard voltage with low power consumption. Continuous and intermittent duty types are available from stock, offering 20, 30, 45 or 60 deg (max) rotation. Typical intermittent (40 per cent) duty model offers 12 in-lb torque at 115 v. Solenoid closes in approximately 0.020 sec.

Class H insulation and material are said to permit high temperature, severe duty service. Solid bronze bearings and high-carbon steel shaft are used. The unit is recommended for gaging, packaging, sorting, automatic assembly. Leetronics, Inc., Dept. P-4 Brooklyn 1, N. Y.

For more information—
Circle 32, inside back cover

High Capacity Vibration Isolators

This isolator is rated at 75,000 lb for steady-running applications and 50,000 lb for impact applications. Direct mounting of presses and other machines weighing up to 300,000 lb is said to be feasible and economical with only four isolators and without heavy foundations. Korfund Co., Inc., 48-19C 32 Pl., Long Island City 1, N. Y.

For more information—
Circle 33, inside back cover

Contact Relays

Multi-element mercury-wetted contact relays capable of reliably switching contact loads from microwatts to ½ k for over a billion operations are available now in two, three and four-pole, double-throw contact configurations. Multi-pole construction is obtained by energizing with one coil two, three or four magnetic switches. Each magnetic switch is hermetically sealed in a hydrogen-pressurized glass envelope. Contact surfaces are continuously wetted with mercury by a capillary connection to a mercury reservoir.

Contact rating is 5 amp, max, or 500 v, max, 250 va. Contact resistance is 40 milliohm or less; constant with 1 milliohm of original value over the

life of the contact. Rate of operation is 60 cps max. Operating speed is 5 millisec at 2 w coil input. C. P. Clare & Co., 3101 Pratt Blvd., Chicago 45, Ill.

For more information—
Circle 34, inside back cover

Hysteresis Synchronous Motor

A line of miniature hysteresis synchronous motors, developed for instrumentation where specific requirements go beyond the capabilities of the conventional synchronous motors, can be supplied for either 8000, 12,000, or 24,000 rpm speeds. With suitable phasing capacitators in the circuit, these motors are adaptable for a single, two or three-phase supply. J. B. Rea, 1723 Cloverfield Blvd., Santa Monica, Calif.

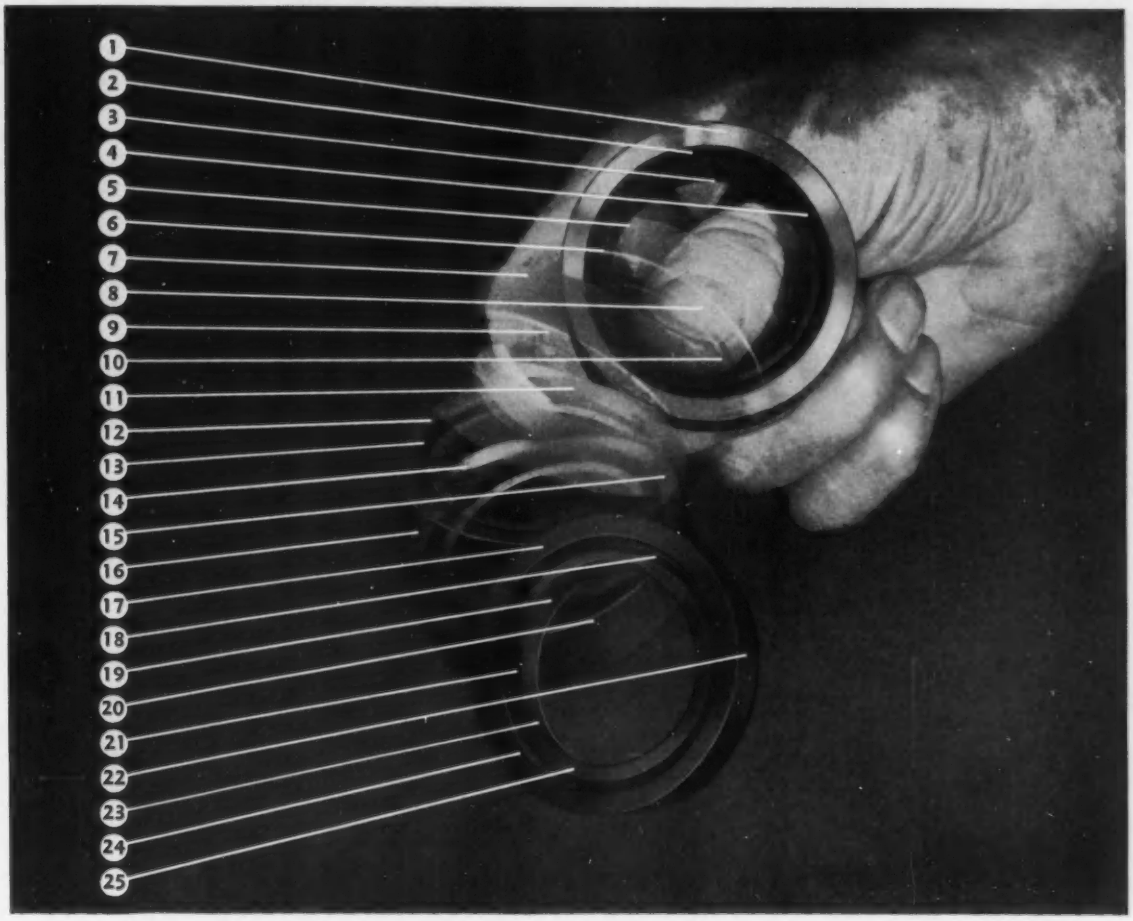
For more information—
Circle 35, inside back cover

Geared Servo Motors

These geared motors are a combination of precision servo motors and precision gear trains of the same diameter, 1.062 in.; length ranges up to 2.219 in.

The motor is designed for 400 cps operation at either 115 or 226 v, but can be wound for other voltages on either phase if desired. The motor, without gearing, has a normal stall

CONTINUED ON PAGE 238



There are 25 reasons why your oil seals must be custom engineered

Before you buy a "stock" oil seal, ask yourself, "Will this seal suit my requirements?". If it does, it should answer 25 different conditions.

As an example, consider the seal assembly . . . Is the seal to have lip clearance? — Is the seal to be pressed in lip first or heel first? — Is the seal pressed in to a predetermined depth? — Is this a vertical or horizontal application? It is highly unlikely that a "stock" packing can meet all 25 requirements.

IPC custom-engineers every oil seal to suit your specific application. Before you buy, consult IPC. No obligation . . . IPC will show you how to simplify design, reduce cost, and insure long effective service. Technical data sheets outlining these 25 points will be mailed on request.

INTERNATIONAL PACKINGS CORPORATION

Bristol, New Hampshire

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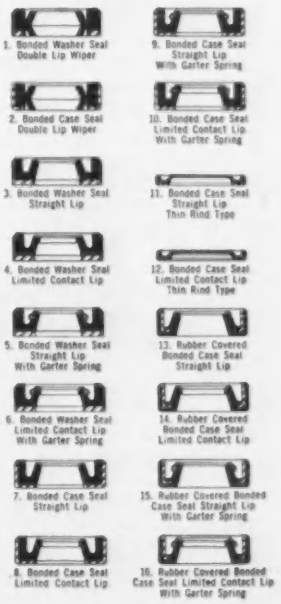
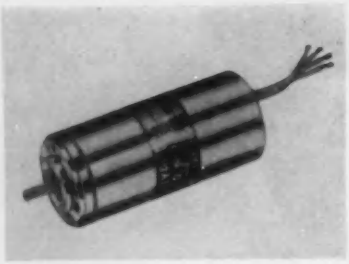

1. Bonded Washer Seal Double Lip Wiper
9. Bonded Case Seal Straight Lip With Garter Spring
2. Bonded Case Seal Double Lip Wiper
10. Bonded Case Seal Limited Contact Lip With Garter Spring
3. Bonded Washer Seal Straight Lip
11. Bonded Case Seal Straight Lip Thin Rind Type
4. Bonded Washer Seal Limited Contact Lip
12. Bonded Case Seal Limited Contact Lip Thin Rind Type
5. Bonded Washer Seal Straight Lip With Garter Spring
13. Rubber Covered Bonded Case Seal Straight Lip
6. Bonded Washer Seal Limited Contact Lip With Garter Spring
14. Rubber Covered Bonded Case Seal Limited Contact Lip
7. Bonded Case Seal Straight Lip
15. Rubber Covered Bonded Case Seal Straight Lip With Garter Spring
8. Bonded Case Seal Limited Contact Lip
16. Rubber Covered Bonded Case Seal Limited Contact Lip With Garter Spring

Branch Offices: Chicago, Dallas, Detroit, Kansas City, New York, Philadelphia, San Francisco, St. Louis.

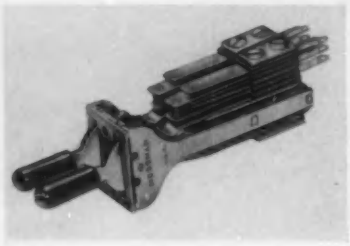
P3



torque of 0.63 oz-in., and a no-load speed of 6200 rpm.

Gear train output ranges from 6 to 1275 rpm, no-load speed. Corresponding stall torques range from 60 to 3.3 oz-in. G-M Laboratories, Inc., 4300 N. Knox Ave., Chicago 41, Ill.

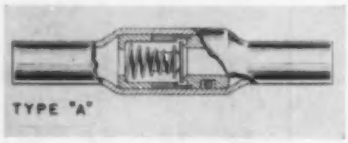
For more information—
Circle 36, inside back cover



Two-Lever Switch

A telephone type lever switch with two levers and cams on the same frame has been introduced. Each lever operates the contacts in two of the four spring pile-ups. Two switches with levers on ½ in. centers are thus provided on the same frame. Donald P. Mossman, Inc., Brewster, N. Y.

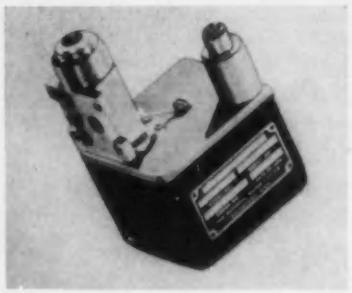
For more information—
Circle 37, inside back cover



Check Valve in One-Piece Housing

Tubular housing is said to make leakage and tampering impossible. The valves are intended for medium and low-pressure applications and in the capillary sizes for higher pressures. The material and thickness of the housing can be specified to match the material, bursting pressure and safety factor of the line. Size range at present is from capillary through 1 in. OD. MCD Mfg. Co., 3218 Barker Ave., New York 67, N. Y.

For more information—
Circle 38, inside back cover



Metering Valve

This single-stage torque motor-driven valve converts an electrical signal to a straight-line gradient response for either hydraulic signal or pneumatic applications. Operational pressure is 0 to 1500 psi, hysteresis, 3 per cent max, delivery 150 cu in. per min at full current differential. National Water Lift Co., 2220 Palmer Ave., Kalamazoo, Mich.

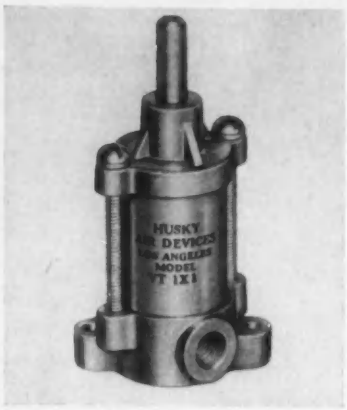
For more information—
Circle 39, inside back cover

Steel Needle Valves

Steel-bodied bar stock needle valves are available for general applications in controlling the flow of liquids or gases. Available from ⅛ to ½ in. in straight or angle patterns, the valves can be supplied with either O-ring seals or conventional packing.

Bar stock valves with carbon steel bonnets and stainless steel bodies are available for high temperature applications up to 750 F. Hoke, Inc., 197 So. Dean St., Englewood, N. J.

For more information—
Circle 40, inside back cover



Air Cylinders

These 1-in. bore cylinders are available in four different mounting models, vertical thrust, vertical face, trunnion and horizontal, making them easily adaptable for such operations as clamping, ejecting or work feeding.

All four models are available in the spring-return, as well as double-acting, types. In the double-acting type both advance and retract strokes are powered. Both types are being produced with 1, 2, and 3 in. strokes. The cylinders are precision machined from hard drawn brass cylinders, aluminum alloy castings, and neoprene-sealed pistons. Husky Air Devices, 1320 E. 16 St., Los Angeles 21, Calif.

For more information—
Circle 41, inside back cover

High-Capacity Motor Capacitors

Type KNT is encased in a deep-drawn, no-seam, solderless terne plate container with base dimensions 4⅞ x 2⅞ in. Type KXT comes in an extra-deep-drawn, no-seam, terne plate case

CONTINUED ON PAGE 240

problem

CMP
RESTRICTED SPECIFICATION
COLD ROLLED STRIP STEEL
Processed to meet special gauge tolerances and provide special finishes and physical properties . . . solves many fabrication, cost & performance problems.

Helping to overcome metal fabricating difficulties, improving products without skyrocketing costs or just getting costs down are usual events with **CMP.**

For example, the manufacturer who was heat-treating formed steel parts subsequently assembled with other components into a powered unit. The forming involves severe deformation and was hampered by lack of uniformity in the annealed strip steel. Distortion in the heat treatment followed, resulting in a low percentage of finished assemblies passed as satisfactory.

To minimize these fabricating difficulties, **CMP** developed a special annealing process for the strip. Using this steel, parts, when subjected to the manufacturer's standard heat-treating practice, were acceptable and yield was greatly increased.

At **CMP,** processing cold rolled strip steel to restricted specifications has been reduced to an exact science and **CMP** men have been trained to spot opportunities for solution of production cost and product improvement problems through application of restricted specifications.

Why not put your problems up to a **CMP** man?

C M P

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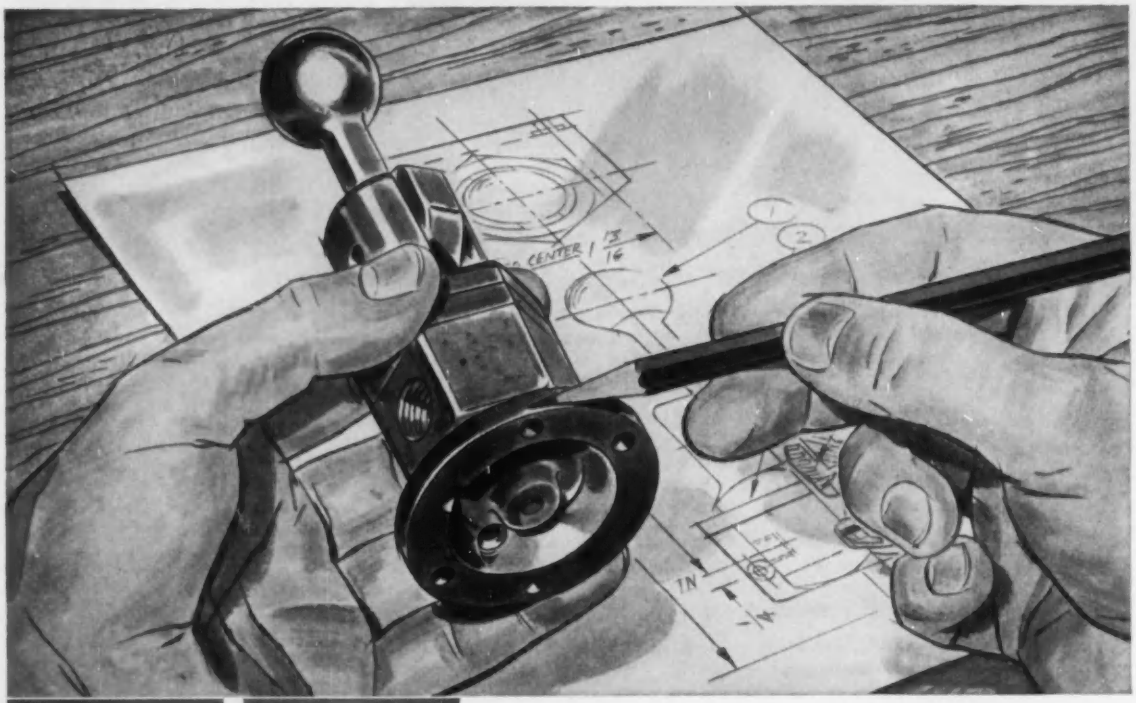
GENERAL OFFICES: YOUNGSTOWN 1, OHIO
PLANTS: YOUNGSTOWN, OHIO AND INDIANAPOLIS, IND.
SALES OFFICES: NEW YORK CLEVELAND DETROIT INDIANAPOLIS CHICAGO LOS ANGELES SAN FRANCISCO

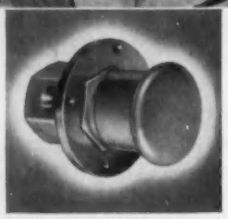
solved

CMP
RESTRICTED SPECIFICATION
COLD ROLLED STRIP STEEL
is available in
Low Carbon Grades • High Carbon Spring Steel (annealed and tempered) • Stainless Types • Alloy Grades • Electro Zinc Coated

Simplified design . . . versatile mountings . . . distinguish new MAC pilot valves



NEW FOOT VALVE—small and compact, has adequate treadle area. Anchors easily.



NEW PALM-BUTTON VALVE—suitable for panel mounting. Returns to normal position.

NEW SOLENOID VALVE—instant action. Protective cover is easy to remove.

NEW CAM VALVE—built-in overtravel prevents damage when operated by cam series.

NEW HAND VALVE—available in either locking or non-locking type. May be used singly or in series for working pressures up to 150 P.S.I.

Design makes the difference in these pilot valves. And it's easy to spot. MAC's new pilot series is trim and compact. The valves are lightweight, and smaller . . . have fewer parts. By simplifying design, MAC engineers virtually eliminated maintenance . . . built in dependability for millions of cycles.

You'll find MAC pilot valves tops for convenience, too. A variety of mountings mean they can be installed almost anywhere—close to hand or foot, or overhead and out of the way. And, of course, this new pilot series reflects the precision and quality workmanship that mark *all* MAC valves.

So, look to MAC for *all* your air valve needs—solenoid, pilot operated *and* pilot . . . any size or type. We've got the answer *—and exactly the right valve*—for any air control problem. Write us or contact a representative listed at the side.

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MECHANICAL AIR CONTROLS, INC.
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MAC

with base dimensions 2 7/16 x 2 1/8 in. and case heights up to 7 3/8 in. max. Both types are ideal for motor-running applications in split-phase motor circuits such as in air conditioning and refrigeration equipment, voltage regulators, fan motors, business machines. They may be used also in power-factor improvement and for general purpose a-c applications.

Maximum ratings available in type KNT are 40.0 mfd at 236 v, 37.0 mfd at 300 v, 35.0 mfd at 330 and 350 v and 25.0 mfd at 440 v. Maximum values in the KXT are 30.0 mfd at 236 v, 25.0 mfd at 330 and 350 v and 20.0 mfd. at 440 v. Cornell-Dubilier Electric Corp., S. Plainfield, N. J.

For more information—Circle 42, inside back cover

Single-Pole, Single-Circuit Switch

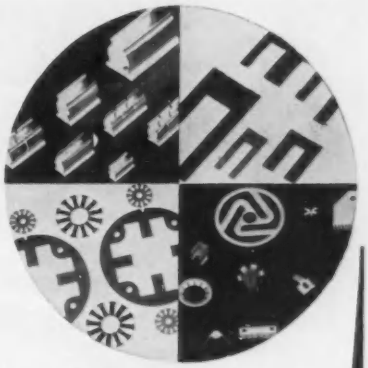
Dimensions of this unit are 1 1/4 x 1 7/8 x 1 5/8 in. long. The stem has a 1/4 in. dia and 1/2 in. length. UL-approved, it is rated for 20 amp at 125 v. McGill Mfg. Co., Inc., Valparaiso, Ind.

For more information—Circle 43, inside back cover

Flanged, Silent Check Valve

This check valve is recommended by the manufacturer for control of water hammer for all types of hot or cold liquid service, including water, oils, gasoline, acids, chemicals, salt water, brine, where flow is constant.

(Continued on page 242)



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Beryllium Copper
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Some immediately available. Others rolled to order in 2 to 21 days. Can be supplied in coils or straight lengths with slit or filed edges—also cadmium plated.

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These PRESTOLE fasteners, featuring the outstanding PRESTOLE impression, can be made to special specifications. In most cases new tooling is not required. Therefore, quantity delivery to your production is possible immediately, and costs are reduced.

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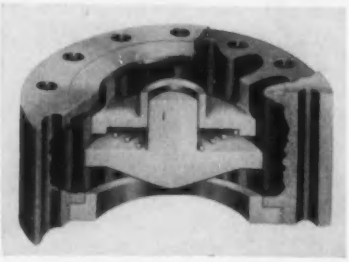
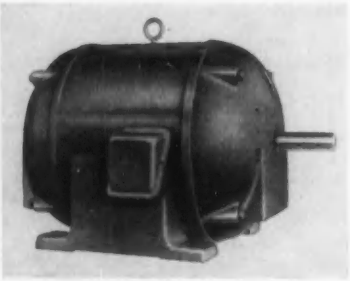
Application



It is available in sizes from 1 to 10 in., faced and drilled in accordance with ASA standard for pressures ranging from 125 to 2500 lb. The valve can be furnished with special flange facings, including large male and female, ring joint, and large tongue and groove. Williams Gauge Co., Inc., 2 Gateway Center, Pittsburgh 22, Pa.

For more information—
Circle 44, inside back cover



Electric Motors, 1/6 to 125 Hp

This line of motors has 40 C rise and are now splash-protected. Both old and new NEMA frames are available at the same price. Motors are offered in $\frac{1}{6}$ to 125 hp, with 900, 1200, 1800 and 3600 rpm ratings, for 208, 220, 440 or 550 v, 50 and 60-cps power supplies. Marble-Card Electric Co., Gladstone, Mich.

For more information—
Circle 45, inside back cover

A-c Servo Motor

A 60-cps servo motor which is expected to find application in instrumentation, controlling and servo-system fields is $1\frac{1}{4}$ x $2\frac{1}{4}$ in. long. Both two-pole and four-pole machines are available with either hysteresis or induction-type rotors. The hysteresis models have very good low voltage performance with complete absence of any "cogging" effect. The induction

(Continued on page 246)

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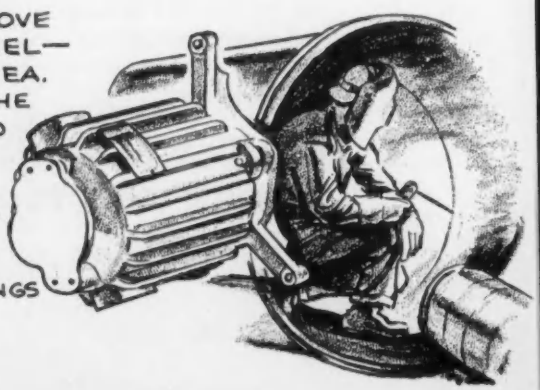
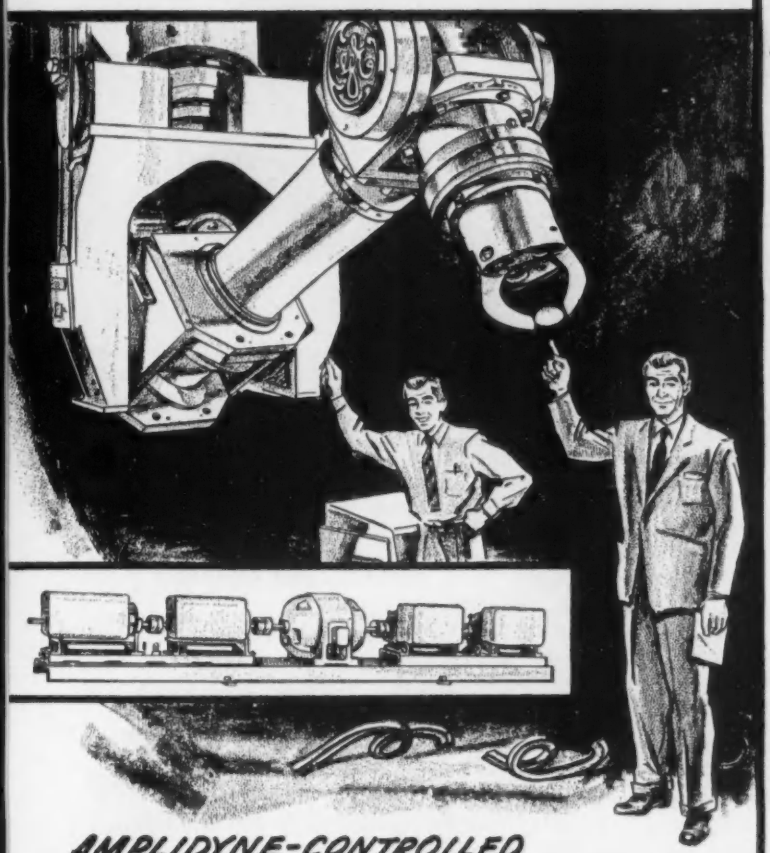
SOME UNUSUAL DESIGN FEATURES: DOUBLE ROTOR CONSTRUCTION PERMITS UTILIZATION OF SINGLE OR DUAL POWER SOURCES; USE OF NEWLY DEVELOPED G-E INSULATION SYSTEM PROTECTS AGAINST INTENSE HEAT; AND SPECIAL ROTOR CONFIGURATION PROVIDES HIGH STARTING TORQUE AND HIGH OPERATING EFFICIENCIES.

THIS SPECIALLY COOLED G-E MOTOR OPERATES WHERE DEPENDABILITY CAN MEAN LIFE ITSELF!

THIS G-E MOTOR DRIVES A VENTILATOR TO EXHAUST WELDING FUMES WHICH CAN PROVE DEADLY IN THIS UNDERGROUND CABLE TUNNEL—OR IN A SHIP'S HOLD OR ANY ENCLOSED AREA. DEPENDABILITY IS IMPERATIVE. DESIGN OF THE TOTALLY-ENCLOSED MOTOR (TO BE MOUNTED INSIDE BLOWER) POSED THE PROBLEM OF DISSIPATING MOTOR HEAT. G-E ENGINEERS SOLVED THE PROBLEM BY BUILDING THE MOTOR WITH SPECIAL HEAT-DISSIPATING RIBS. AN INTERNAL FAN TRANSFERS HEAT FROM THE WINDINGS WHILE THE BLOWER ITSELF BRINGS COOLING AIR OVER THE RIBBED HOUSING.



specialty motors



AMPLIDYNE-CONTROLLED MECHANICAL ARM HAS FINGERS THAT TWIST STEEL OR HANDLE AN EGG

A G-E MULTIPLE AMPLIDYNE SET CONTROLS THE MUSCLES OF O'MAN, AN OVERHEAD MANIPULATOR BUILT BY GENERAL ELECTRIC. O'MAN CAN KNOT STEEL BARS, YET DEMONSTRATES A DELICATE TOUCH WHEN IT LIFTS AN EGG WITHOUT BREAKING IT. O'MAN IS THE WORLD'S LARGEST MECHANICAL ARM BUILT TO SUBSTITUTE FOR HUMAN BRAWN IN RADIO-ACTIVE AREAS.

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IN SHORT ORDER A SAMPLE G-E MOTOR IS READY FOR TESTING ON YOUR PRODUCTS.

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WRITE FOR MORE INFORMATION COVERING G-E EQUIPMENT DESCRIBED IN THIS AD TO GENERAL ELECTRIC CO., SECT. 633-3, SCHENECTADY 5, N.Y.

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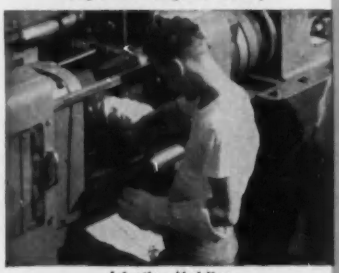

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The United States Gasket Company is the recognized leader in the fabrication and application of the "Wonder Plastics", duPont TEFLON, Kellogg KEL-F and BAKELITE Fluorothene—leadership earned through many years of pioneering.

Today, this company offers engineering and manufacturing talent and facilities unmatched in the industry to assist its customers in the profitable application of Fluorocarbon Products for almost countless purposes.

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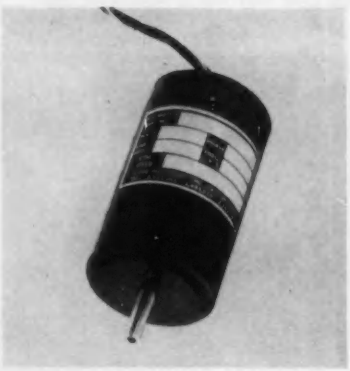


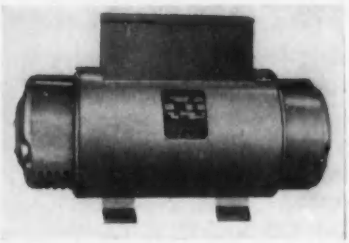
rotors are aluminum bar design and have higher torque capacity than the hysteresis type. Globe Industries, Inc., 1784 Stanley Ave., Dayton 4, Ohio.

For more information—
Circle 46, inside back cover

Nylon Tube Fitting Requires No Flaring

Made in two pieces, this fitting is 1/17 the weight of comparable brass units, has a temperature range from 70 to 295 F, and has a positive leakproof and vibration-proof seal which will withstand pressure up to 500 psi. The fitting is available from ⅛ to ½ in. in all variations. Jaco Mfg. Co., P.O. Box 2659, Cleveland 7, Ohio.

For more information—
Circle 47, inside back cover



Motor-Alternator Sets

These units are said to include a new alternator of mono-coil design, static d-c exciter, magnetic amplifier-type voltage regulator, permanently lubricated ball bearings, dripproof enclosure, ±2 per cent voltage regulation, and recovery time of 0.25 sec or less. The manufacturer says these units are especially designed to provide a source of dependable 400 cps power. With the standard induction motor drive, the frequency regulation

(Continued on page 250)

412 lb. 'Jeep' engine

Jockeys 78,000 lb. railroad cars

'Jeep'-powered Whiting Trackmobile moves railroad cars, with loaded weight of 39 tons, to dumper. 'Jeep' Industrial Engine supplies high torque needed in this vehicle on track or when moving on rubber tires from job to job, road or unpaved ground.

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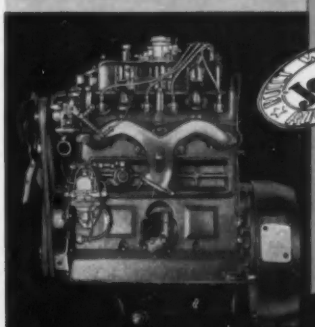

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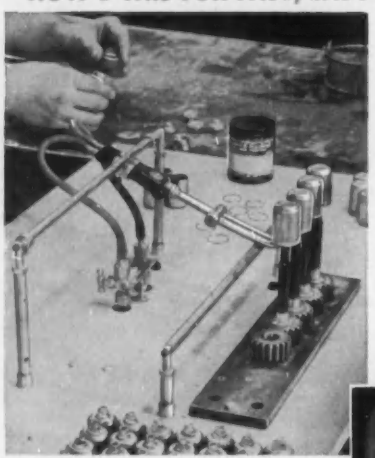
This simple safety device is used on railroad bearing boxes and all kinds of machines and equipment to give warning when temperature rises to a danger point. It comes filled with an odorous gas or with smoke, under pressure, held in by an alloy plug that has a fusing temperature to fit the application.

It's made of a drawn brass shell and a brass screw machine made cap, brazed with EASY-FLO 45. This low-temperature silver brazing alloy is used because – *it naturally and consistently makes gas-tight joints* that have the properties to stay gas-tight permanently–namely–high strength with resistance to pressure, vibration, shocks, heat changes and corrosion equal to the metals joined. In addition, EASY-FLO 45 makes brazing an extremely simple, economical operation.

EASY-FLO 45 RING

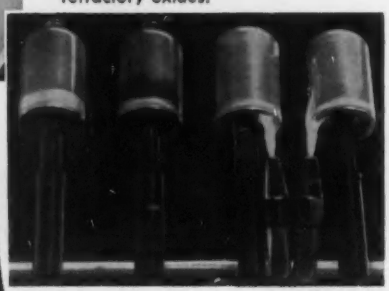
HOW'S THIS FOR FAST, EASY METAL JOINING



Above are the parts with ring of EASY-FLO 45 wire in place. At left —Operator applies HANDY FLUX*, puts shells over alloy ring and cap, sets assemblies, cap down, on geared spindles. Below—2 assemblies are brazed at a time on the slowly revolving spindles with double-tip torch — heating time, 12 seconds.

*Working at 1100°F, HANDY FLUX is a "must" to get full benefit of EASY-FLO 45's low flow point of 1145°F. Besides, it is unsurpassed as a dissolver and absorber of refractory oxides.

HEAT WARNERS are products of Humphrey-Wilkinson, Inc. Chemical Manufacturers of North Haven, Conn. Equipment by Specialty Brazing Laboratory, Riverside, Conn.



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is 406 to 418 cps. These units may be operated on either 208, 220, 440, or 550 v, 60 cps power, and are now available in three-phase outputs from 500 w to 5.0 kw. Hertner Electric Co., 12690 Elmwood Ave., Cleveland, Ohio.

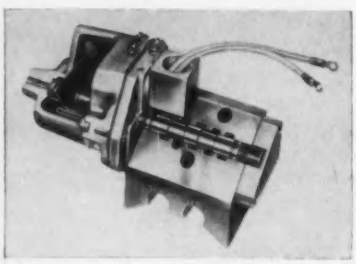
For more information—
Circle 48, inside back cover

Miniature Indicator Lamp

This lamp is said to take up one-half to two-thirds less volume than other assemblies heretofore available. Up to 1000 may be installed in a square foot panel. Standard subminiature incandescent or neon bulbs are replaceable without dismounting. A full range of voltages in either single-contact grounded models or with both terminals insulated are available.

The units have pressure-loaded, 24 carat gold contact springs having highly tempered, spring steel cores. Burnished 24 carat gold is overlayed on all contacts and springs. Circon Component Co., Santa Barbara Municipal Airport, Goleta, Calif.

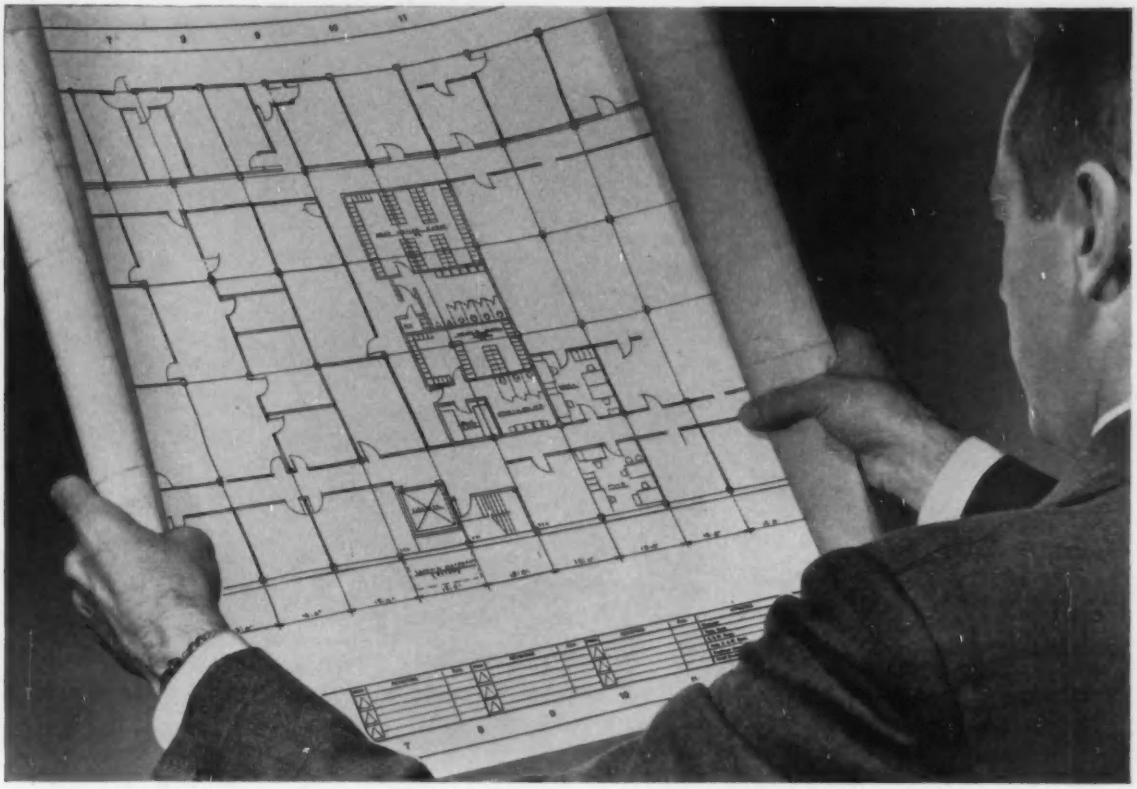
For more information—
Circle 49, inside back cover



Multi-Purpose Spool Valve

This fast valve is reported to complete a valve cycle within 0.033 sec. With working surfaces almost as hard as a diamond, the valve is engineered and built to tolerances of 0.0001 in. It is available with ¼ or ⅜ in. pipe tap for in-line, manifold or base mounted,

(Continued on page 254)



Kodagraph Autopositive intermediates have dense black photographic lines on a translucent paper base.

To show alternate floor plans and elevations

Instead of retracing basic plans over and over, you reproduce them on Kodagraph Autopositive Paper.

This revolutionary paper gives you positive photographic intermediates *without a negative step.*

You, or your blueprinter, can turn them out under full roomlight with present equipment. Expose in a blueprint or direct-process machine . . . or vacuum frame; process in standard photographic solutions.

Result: Sparkling intermediates made at a fraction of the retracing cost! Just add the new design . . . and you have printmaking masters which will give you top-quality blueprints and direct-process prints.

This is another example of the way Kodagraph Reproduction Materials save time, cut costs in thousands of drafting rooms and reproduction departments.

EASTMAN KODAK COMPANY
Graphic Reproduction Division, Rochester 4, N. Y.

New booklet is jam-packed with valuable tips on saving drafting time, protecting drawings, getting better prints.

Kodagraph Reproduction Materials

MAIL COUPON FOR FREE BOOKLET

EASTMAN KODAK COMPANY
Graphic Reproduction Division, Rochester 4, N. Y. 15

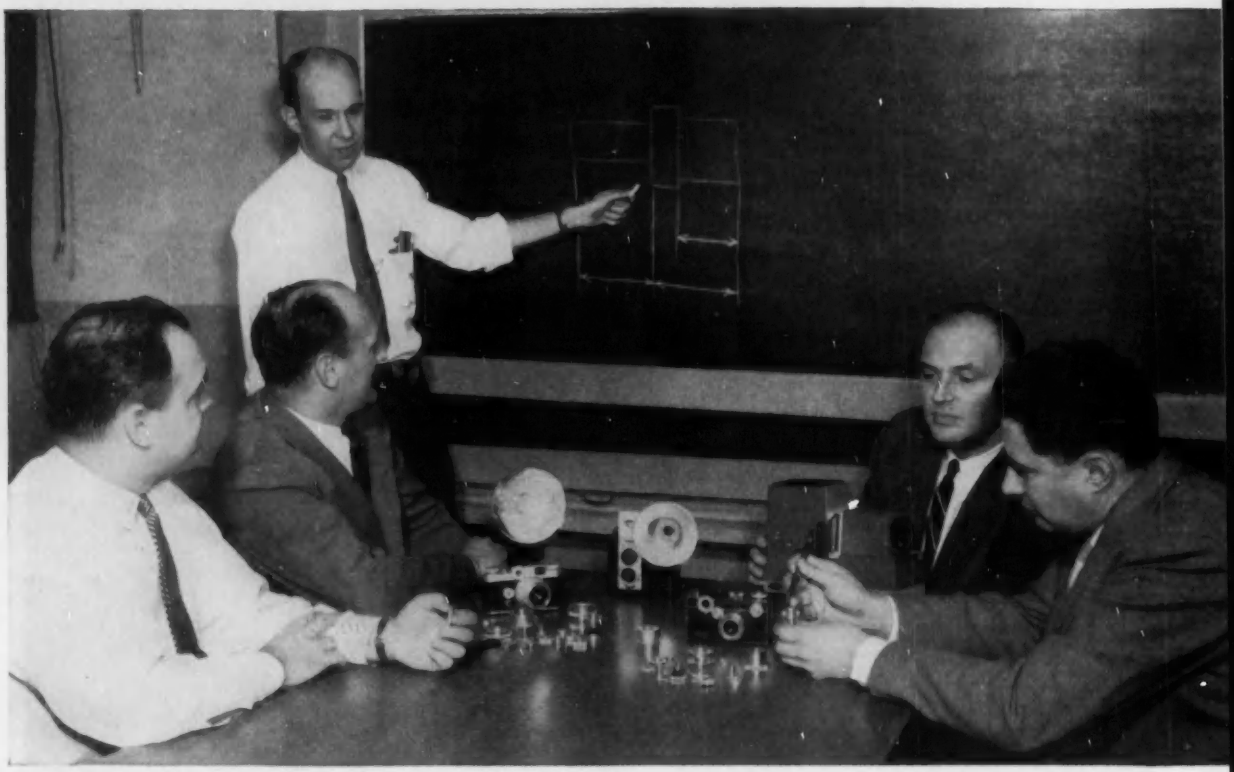
Gentlemen: Please send free booklet describing Kodagraph Reproduction Materials.

Name_____

Company_____ Position_____

Street_____ City_____ State____

Kodak
TRADE-MARK



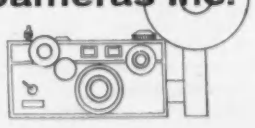
A typical new product planning session at Argus includes, from left to right: N. L. Symons, Director of Purchases; G. D. Flannery, Purchasing Agent; M. K. Carr, Chief Product Engineer; J. N. Steel, Advertising Manager; C. F. Myers, Superintendent of Mechanical Processing.

A VISIT TO ARGUS* TO SEE WHAT THEY'RE DOING WITH ALCOA SCREW MACHINE STOCK

Born in the depths of the 1931 depression, Argus Cameras, Inc., now occupies the country's leading position as a manufacturer of 35 mm cameras. Aluminum plays a major role in making the broad Argus line of photographic equipment light, lasting and above all salable. Projector housings are die cast in aluminum. Lens housings, rewind knobs, focusing mechanisms are made of Alcoa® Aluminum Screw Machine Stock. One characteristic is common to all screw machine parts made by Argus. That characteristic is precision. Tolerances in "tenths of thousands" are commonplace. Diamond turned finishes are routine. Jewel-like appearance is a production byword.

Although quality appearance is mandatory at Argus, it may not be a requirement of your product. Consider, then, the other reasons why the trend to aluminum screw machine parts can no longer be bucked: excellent machinability of today's free-cutting Alcoa alloys . . . electrical and thermal conductivity . . . corrosion resistance. High performance of the finished part, coupled with the solid economic fact that you get three times as many parts per pound as with heavy metal, makes up the total "good sense" of aluminum. These are hard commercial reasons why aluminum, more than ever before, should be carefully considered for every screw machine part you make or specify. Help in this type of analysis is available for your product from every one of Alcoa's local sales offices listed in your phone book under "Aluminum." ALUMINUM COMPANY OF AMERICA, 865-E Alcoa Building, Pittsburgh 19, Pennsylvania.

★argus Cameras Inc.



Purchasing session on aluminum screw machine parts and stock is held by: N. L. Symons, Director of Purchases (left) and Purchasing Agents, L. H. Thomas (center) and G. D. Flannery (right).

IN PURCHASING

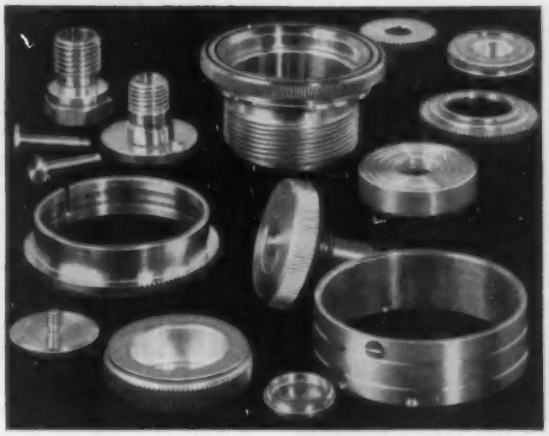
"Our purchasing department at Argus demands dependability from suppliers. It is this single fact that has characterized our relationship with Alcoa over the past 11 years. We have never had a reject of Alcoa Screw Machine Stock. Alcoa's research and development aid are always available when needed. We don't believe you could ask more of a supplier than we get willingly from Alcoa."

IN DESIGN

"The low cost of aluminum is a tremendous factor in the manufacture of a volume product like cameras. But beyond that, we in design lean heavily on aluminum for the better product it makes possible. Light weight and corrosion resistance are mandatory in cameras. The permanent black anodized finish, possible with aluminum, has led to its use in place of brass for some parts like lens-retaining rings. Freedom from plating makes parts like lens mounts and focusing mechanisms more practical in aluminum than brass or steel.

"In design considerations, the combination of Alcoa literature and Alcoa technical assistance gives us firm foundations of fact on which we can make decisions."

Design consultation on aluminum parts includes: Chief Product Engineer, M. K. Carr (standing) and Assistant Chief Product Engineer, E. O. Zill (seated).



Typical parts machined by Argus from Alcoa Aluminum Screw Machine Stock.

IN PRODUCTION

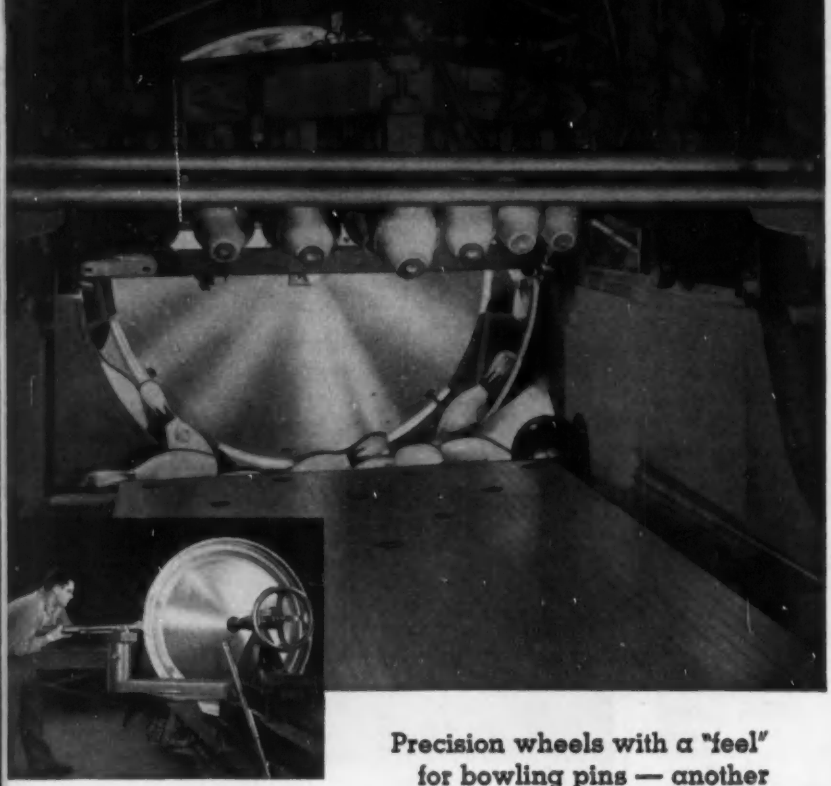
"We machine aluminum at tremendous feeds and speeds. Many of our parts require 75% stock removal. For these, the machinability of aluminum and its high scrap value stand us in good stead. The fine finish, so necessary to camera parts, is easily attainable with Alcoa Screw Machine Stock. And in this respect, consistency of quality from one shipment to the next is perhaps the place where Alcoa serves us best. Fine threads and close tolerances are second nature to us. We like the way aluminum gives us these qualities without constant tool change and lost setup time."

Inspecting fine finish on aluminum lens mounts are: A. E. Danner, Shop Foreman (left) and C. F. Myers, Superintendent of Mechanical Processing (right).

Your Guide to the Best in Aluminum Value

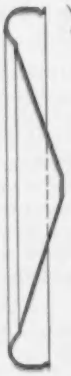
Spincraft did it for AMF . . .

Spincraft can do it for you!



NINE DIFFERENT OPERATIONS—
Spinning and forming tolerances to .031"

On each 5-ft. wheel, Spincraft assumed 100% fabricating responsibility: deep draw, spin, punch, blank, stamp and form, pantograph (chamfer), surface finish, drill, rivet, carton and ship. Operator (above) is spinning the ⅛-in. thick sheet of tough 52S aluminum alloy. Cross-section of basic wheel (right) shows unusual contour requirements. Raised segments are ⅛-in. cold rolled steel.



Write for Spincraft data book. If you have a specific problem, tell us about it — no obligation.

Precision wheels with a "feel" for bowling pins — another example of Spincraft's fabricating skill

By setting pins faster, American Machine and Foundry's automatic pin spotter gives more bowlers more opportunities for better scores! Spincraft is proud to have successfully fabricated a key component of the AMF pin spotter. It's the large-diameter pin elevator wheel — our solution to a difficult production problem for this well-known manufacturer.

This is *one more* example of Spincraft's versatility, capacity and skill. We offer complete facilities for contract manufacture of metal parts or complete units. No jobs are too big — or too small. One piece or millions are taken in stride.

Engage the facilities of the world's largest metal spinning plant — the only such plant also equipped for deep drawing, stamping and complete fabrication. You'll get results and savings that far exceed your expectations!

SERVING INDUSTRY SINCE 1919 . . .

World's largest plant fully equipped for all types of metal spinning • deep drawing • stamping • fabricating

Spincraft
SKILL WILL DO IT
INCORPORATED

4124 WEST STATE STREET • MILWAUKEE 8, WISCONSIN

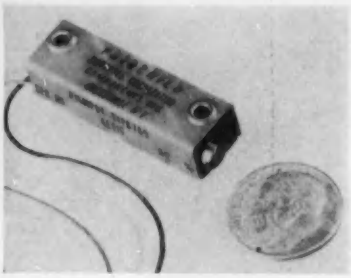
in single solenoid spring return, double solenoid momentary and double solenoid three position. These solenoid direct-operated four-way spool-type valve arrangements can be used for straight-way or three-way functions by plugging ports. The valve measures 7¼, 3½, 3⅞ in. Flow capacity is equal to a ¼ in. dia hole. Ross Operating Valve Co., Detroit 1, Mich.

For more information—
Circle 50, inside back cover

Miniature Rectifiers

These selenium rectifiers have $\frac{5}{16}$, $\frac{7}{16}$ and ½ in. dia plates. Half-wave type are supplied from 0 to 148 v, peak inverse, full-wave types from 0 to 74 v peak inverse with ratings to 25 ma dc. Bradley Laboratories, 169 Columbus Ave., New Haven 11, Conn.

For more information—
Circle 51, inside back cover



Potentiometer for —57C to 125C

With a precious metal film resistance element, this potentiometer provides infinite resolution throughout the 28½ turn adjustment screw travel. Linearity of 5 per cent is standard for resistance element values ranging from 50 to 25,000 ohm. This model is ⅛ x 13/22 x ⅞ in., overall. Fairchild Controls Corp., 6111 E. Washington Blvd., Los Angeles 22, Calif.

For more information—
Circle 52, inside back cover

Variable Speed Drives

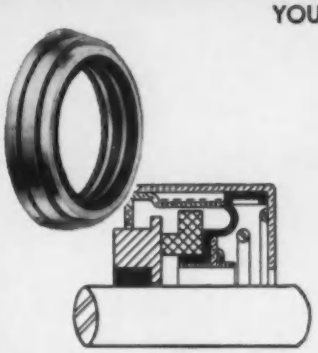
Normal speed range is 22:1 but is available in speed ranges as great as 60:1. With tachometer feedback, speed can be controlled to within 0.25 per cent. Power supply is from a-c single-phase voltages of 110, 208, 220,

(Continued on page 258)

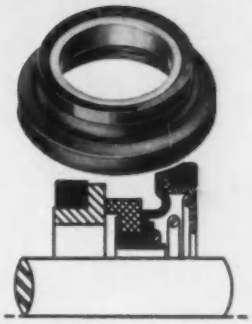
LARGEST STOCK SELECTION AVAILABLE ANYWHERE!

Modern, Mechanical, Face-Type Seals —
Standardized, To Save Time And Money

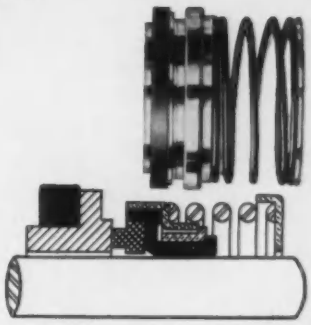
YOUR Sealing Problem Is Solved Here!



STYLE GU — A packaged sealing unit containing both rotating and stationary seal faces enclosed in metal housing. Important applications in machine tools and power transmission equipment. Stock sizes for shafts .250 through 4.000.

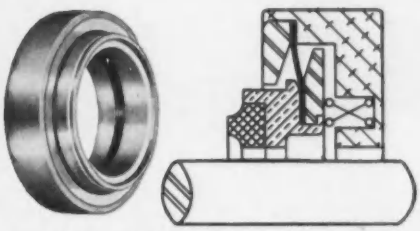


STYLE SGU—A factory-assembled unit-type seal for the small budget user. Widely used in appliance field. Stock sizes for shafts .250 through 1.000.

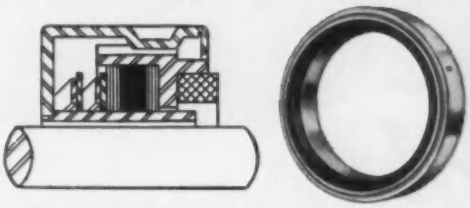


ROTO-FLEX — Rugged flexibility. Only 3 parts. Single or double units. Many applications in pumps and compressors. Stock sizes for shafts .250 through 4.000.

STYLE RFO—A specially designed Roto-flex seal, for installation outside the stuffing box. Stock sizes for shafts .250 through 4.000.



STYLE DPC — A high-speed, carbon-faced seal, for use where lubrication is poor or where shaft RPM and resulting friction are high. Ideal in many machine tool applications. Stock sizes for shafts .250 through 4.000.



STYLE HH—Absolute minimal space (both radial and axial) under extreme conditions of temperature, pressure and seal face surface speed. Features pressure balance when fluid pressure is applied internally or externally. Of particular importance to the aircraft industry. Stock sizes for shafts .250 through 4.000.

These are only a few of the countless sealing problems now being solved by

GITS SHAFT SEALS

Write for detailed data on any of these standardized stock Gits Shaft Seals.

GITS BROS. MFG. CO.
1838-B S. KILBOURN AVE., CHICAGO 23, ILL.

Specialists In Lubricating Devices And Shaft Seals For Almost Half A Century

JACK OF ALL TRADES... AND MASTER OF EACH!

New WILCOTROL SERIES G

Here is a versatile new thermostat for both heating and cooling applications... higher rated for new heavy-duty appliances and medium industrial requirements. Interchangeable with former Model F, the new Series G provides for differential factory adjusted to customer's specification, simplified calibration adjustment, and a contact mechanism not affected by vibration.

Other new features include screw type or quick connect terminals, Positive Off Position-Type G-1 (heater load). "Constant cool" position optional on Type G-2 (cooler load). Universal mounting bracket, and terminal cover where required. For full information on the new Series G, contact The Wilcolator Co., 1001 Newark Ave., Elizabeth, N. J. Canadian plant: Mimico, Toronto, Canada.

SPECIFICATIONS:

Standard temperature range: 40°F Minimum, 550°F Maximum.
Special temperature ranges: to customer's requirements
Type G-1: Contacts open on temperature rise
Type G-2: Contacts close on temperature rise
Switch Mechanism: Single pole, double break, snap action
Contact Rating: Type G-1 30 Amp. 125 and 250 volts—AC non-inductive load
Motor Ratings: Type G-2

VOLTS	RUNNING CURRENT	LOCKED ROTOR
120 AC	14 AMP	60 AMP
208 AC	14 AMP	60 AMP
240 AC	14 AMP	60 AMP

Both motor and non-inductive ratings Underwriters listed and approved.
Mounting: Back of panel or in enclosure
Terminals: Screw Type, AMP or Arkles. Standard shaft size—¼" flatted to .156". Length to customer's specification.

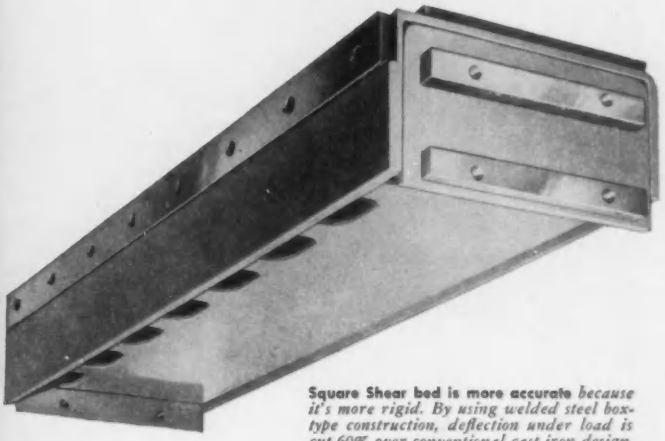
THE Wilcolator COMPANY

When steel is 3 times stronger than cast iron . . .

Has two and one-half times the rigidity...

Yet costs a third as much per pound . . .

WHY aren't more of your products designed for welded steel



Square Shear bed is more accurate *because it's more rigid. By using welded steel box-type construction, deflection under load is cut 60% over conventional cast iron design. Cost of construction is 28% lower than if made from castings. Photo courtesy Famco Machine Company, Kenosha, Wisconsin. View is from underside to show design details.*

HOW TO DESIGN HIGHER ACCURACY

. . . in precision machinery

THE photo shows how key components for modern machine tools are made even more accurate while reducing costs of manufacture.

With steel designs less material is needed, because of steel's greater strength, high rigidity. Using welding, the steel materials can be placed where they do the most good.

Have Lincoln Electric show you how you can incorporate these advantages in your designs now. Write . . .

THE LINCOLN ELECTRIC COMPANY

Dept. 1313, Cleveland 17, Ohio

The World's Largest Manufacturer of Arc Welding Equipment

BOURNS now offers an expanded line of

TRIMPOTS®

...7 stock models of sub-miniature potentiometers to serve many special needs.— at no extra cost!

First there's the 120 Wirewound TRIMPOT, with features common to all other BOURNS TRIMPOTS. It's a 25-turn potentiometer, easily adjusted, and weighing only 0.1 oz. Rectangular in shape, it fits readily into miniature electronic circuits. You can mount it individually, or stack it compactly with standard screws. Mountings are interchangeable with those on all other TRIMPOTS.

The self-locking shaft holds stable settings under extreme environmental conditions. All parts are corrosion resistant. Every unit is inspected 100% for guaranteed specifications. Resistances: 10 to 20,000 ohms, with resolutions as low as 0.2%.

Now, to give designers greater latitude, BOURNS has developed and is manufacturing the following standard models—variations of the Model 120.

120 TRIMPOT
—Carbon
Infinite resolution is provided by the carbon element. Resistances are higher, ranging from 20,000 ohms to 1 megohm.

130 TRIMPOT
—Solder Lug
For wiring direct to the instrument, using soldering iron or dip soldering techniques. Usable range of 98%.

132 TRIMR
—Variable Resistor
High resistances—up to 50,000 ohms in a wirewound rheostat.

209 TWINPOT
—Dual Potentiometer
Two outputs electrically independent, and controlled simultaneously by one adjustment.

160 TRIMPOT
—High Temperature
Operates at 175°C. High power rating: 0.6 watt at 50°C.

230 TRIMPOT
—Humidity-proof
Completely sealed, unit meets MIL-E-5272A Specifications for humidity.

Write for literature on the BOURNS TRIMPOT line.

BOURNS LABORATORIES

General Offices: 6135 Magnolia Ave., Riverside, Calif.
Plants: Riverside, California—Ames, Iowa

440 or 550 v at 50 or 60 cps. Electro Dynamic Div., General Dynamics Corp., Bayonne, N. J.

For more information— Circle 53, inside back cover

Silicone Rubber Compounds

Compounds HT 655 and HT 666 are said to possess basically desirable characteristics of silicone rubber—immunity to ozone deterioration, high and low temperature flexibility and non-stick surface. The HT 655, a 50 durometer methyl base material, is particularly designed for high temperature work and will remain flexible at −65 F. The HT 666, a 60 durometer methyl phenyl base material, has original properties equal or better than those of HT 655 in tear resistance, slightly lower in tensile strength and elongation. It has outstanding low temperature flexibility at −100 F. Connecticut Hard Rubber Co., 407 East St., New Haven 9, Conn.

For more information— Circle 54, inside back cover

Battery-Operated Vibration Meter

An all-transistor portable vibration meter with a self-contained power source, which can be carried and used anywhere to measure the amplitude of vibrations in the 10 to 1000-cps frequency range, uses two ordinary 22½ v dry batteries to provide power. Consolidated Electrodynamics Corp., Pasadena, Calif.

For more information— Circle 55, inside back cover

Self-Aligning Tube Fitting

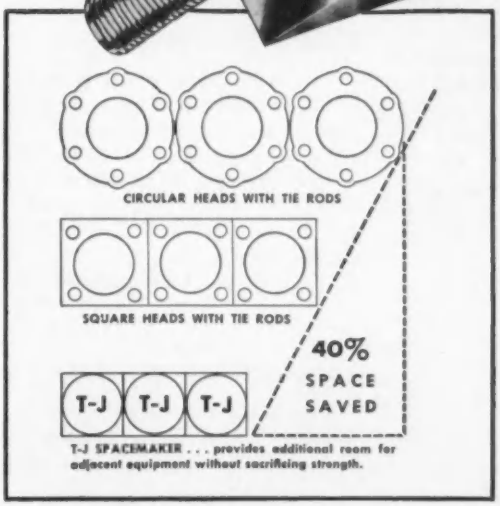
The sleeve grips the tubing over a broad area for a surface-to-surface seal, while a thin razor edge and guiding shoulder form a line-to-line seal with the tubing as the nut is tightened. The fitting is suited for instrumentation and all other low and medium pressure applications using copper and aluminum tubing. The line includes union, union tee, union elbow, male and female connectors, male and female elbows, male tees for pipe on run and pipe on branch. Sizes ⅛, $\frac{5}{32}$, ¼, $\frac{5}{16}$, ⅜ and ½ in. in brass

(Continued on page 260)

Saves 40% Space!

STRONGER, TOO

Than Outmoded Tie Rod Cylinders!



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Only T-J

Spacemaker CYLINDERS

Offer All The Extras As Standard!

- NEW *exclusive* Ingenious Cushion Designs . . . Super Cushion Flexible Seals for Air . . . New Self-Aligning Master Oil Cushion
- Compact design eliminates tie rods, saves up to 40% space
- Proven Performance . . . with Extra High Safety Factor
- Hard Chrome Plated Bodies and Piston Rods (Standard, at no extra cost).
- OIL pressure to 750—AIR to 200 P.S.I.

You'll find many answers to *automation* in your plant with T-J Spacemaker Cylinders! Designed with years-ahead features for top performance and dependability. Wide range of styles, capacities . . . for all kinds of push-pull-lift operations . . . reduces man-hours and costs! Write The Tomkins-Johnson Co., Jackson, Mich.

MEMBER OF THE NATIONAL FLUID POWER ASSOCIATION

T-J TOMKINS-JOHNSON

RIVITORS · AIR AND HYDRAULIC CYLINDERS · CUTTERS · CLINCHORS

ACE®

Controlled-property compounds meet your needs for:

MECHANICAL,

ELECTRICAL,

CHEMICAL APPLICATIONS

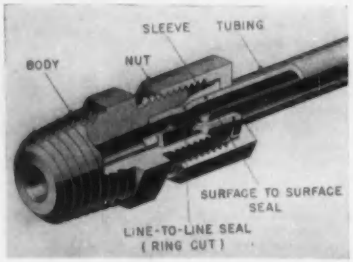
COME to think of it, we're a little amazed ourselves at the way Ace engineers can blend the mechanical, electrical and chemical properties of different rubber and plastic materials. Their aim is always to find the one best material for each of your jobs . . . never *over*designed . . . with production economy a must. Result: hundreds of tailor-made rubber, plastic, and rubber-plastic alloys to choose from . . . plus many unusual materials like Ace-Tex pyrobitumens. Ask us for anything from rough-ground rods to finished molded assemblies. Our facilities for molding, extruding, fabricating, and lining are among the world's largest.

Always check your ACE design engineer's Handbook when selecting materials for today's production and tomorrow's plans. If you haven't a copy, write today! It's Free.

ACE rubber and plastic products

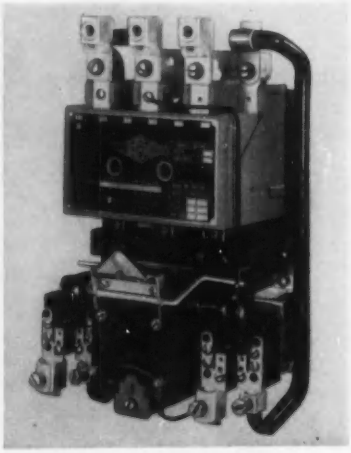
AMERICAN HARD RUBBER COMPANY

93 WORTH STREET • NEW YORK 13, N. Y.



are available from stock; aluminum fittings are special order. Weatherhead Co., 128 W. Washington, Fort Wayne, Ind.

For more information—
Circle 56, inside back cover



Electric Motor Starter

An electric motor starter rated 50 hp, 220 v and 100 hp, 440 v is stocked with its coil connected for 220 v and can be reconnected for 440 v. Coil changing is eliminated and stocking of starters and coils simplified. Furnas Electric Co., 1050 McKee St., Batavia, Ill.

For more information—
Circle 57, inside back cover

Miniature Universal Joint

These joints permit flexible design in solid shaft connections common with small synchros, resolvers, sub-fhp motors, mechanical indicator repeaters, potentiometers, phase shifters or similar devices. Joints pivot on preloaded bearing surfaces which are ground and lapped balls giving continuous contact with zero backlash and low friction. Joints are made of high tensile

(Continued on page 262)

Here's a UNIQUE, ECONOMICAL WAY to buy controls!

If you're making equipment that uses controls . . . for temperature, pressure, vacuum, liquid level, humidity . . . you can profit by a better purchasing plan offered by Honeywell. It's called the—

★ HONEYWELL CONTROLS PURCHASE PLAN

It saves you money—by establishing a planned basis for buying, that gives you the benefit of the most advantageous price. Your savings can amount to as much as 40 per cent!

It saves you trouble—because you don't have to shop around for different controls. The more than 7000 varied types of Honeywell controls cover just about every application you could require. Your specifying and purchasing are simplified . . . and you're sure of the high quality standards and nation-wide service that only Honeywell can offer. Consolidated, single-source buying simplifies your stocking problems, too!

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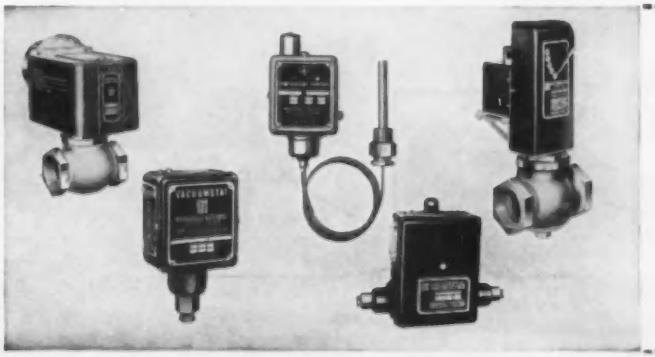
MINNEAPOLIS **Honeywell**

First in Controls



Industrial Division
Minneapolis-Honeywell Regulator Co.
Wayne and Windrim Aves., Philadelphia 44, Pa.

☐ Please send me your catalog on Honeywell Controls.

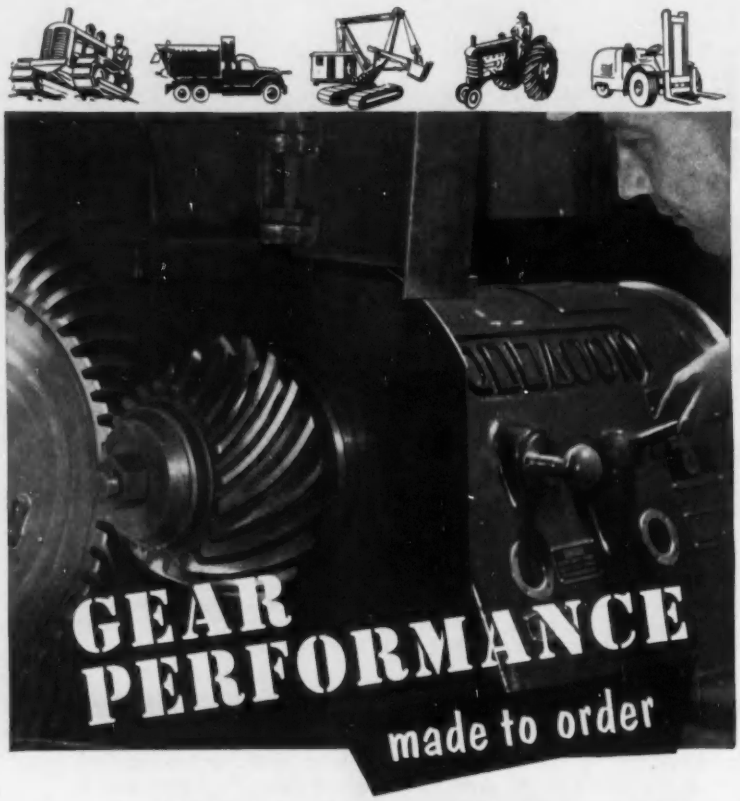
☐ I'd like a Honeywell sales engineer to discuss how the Honeywell Controls Purchase Plan can be applied to my control purchases.

Name _____

Title _____

Company _____

Address _____



by FAIRFIELD

GEAR PERFORMANCE to match the ever-increasing power and speed of modern machines is Fairfield's specialty. This is possible because Fairfield has constantly held a position of leadership in utilizing the most advanced methods, machines, and techniques for producing better gears. By keeping apace with modern engineering trends, Fairfield renders an invaluable service to many of the nation's leading machinery builders: *"Gear Performance Made to Order!"*

Users also get the advantage of Fairfield's *mass production economy* extending over a complete range of gears: Spiral Bevel, Straight Bevel, Hypoid, Zerol, Spur, Herringbone, Worms and Worm Gears, Splined Shafts, and Differentials. Available, too, are expert recommendations for any gear problem users may have. *Ask for interesting, illustrated bulletin describing Fairfield facilities.*

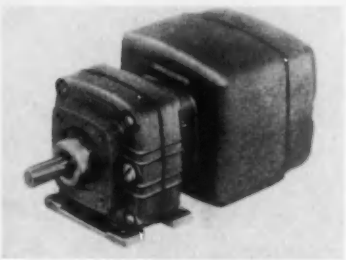
FAIRFIELD
MANUFACTURING CO.

2305
S. Concord Rd.

Lafayette,
Indiana

strength steel alloy. They may be heated, or supplied in stainless steel on order. Shafts to be connected insert into hub holes of the joint. Hub holes available from $\frac{3}{32}$ to $\frac{1}{4}$ in. ID, +0.0005, −0.0000 in., in $\frac{1}{32}$ in. increments. Body diameters from $\frac{3}{16}$ to $\frac{3}{8}$ in., $\frac{1}{16}$ in. increments; body lengths are $1\frac{1}{4}$ and $1\frac{1}{2}$ in. overall. Maximum operating angle 30 deg. from colinear position. Falcon Machine & Tool Co., 209 Concord Turnpike, Cambridge 40, Mass.

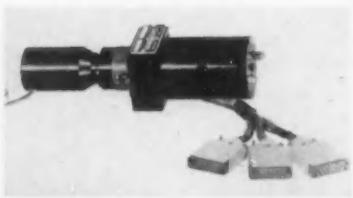
For more information—
Circle 58, inside back cover



Tachometer Takeoff Heads

These tachometer heads measure high speeds, 5000 to 30,000 rpm, or low speeds, $\frac{1}{2}$ to 100 rpm. A double-pole, double-throw switch together with a capacitor acts as a speed sensing element. When the takeoff shaft rotates either direction built-in efficient gearing operates this speed sensing element. It produces a current linear with respect to speed. Metron Instrument Co., 432 Lincoln St., Denver 3, Colo.

For more information—
Circle 59, inside back cover



Motor-Driven Sampling Switch

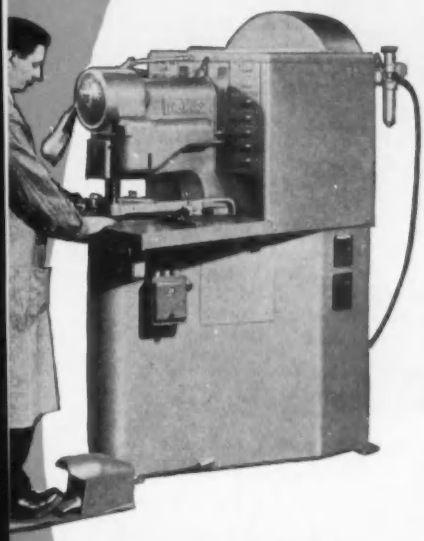
This switch has 20, 30, 40, or 45 contacts per pole, one to four or more poles. Direct current, 60 or 400 cps a-c integral motor is optional. Cables and plugs have one plug per pole. The

(Continued on page 265)

"WALES-WAY" showed us how to SPEED-UP hole punching OVER 50% ...

with the

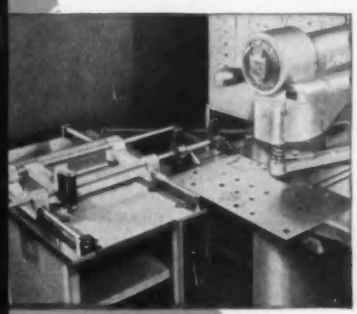
WALES FABRICATOR



Here's a big money maker in any sheet metal shop. Punches and dies for round and shaped holes take only seconds to remove and replace. Complete sets are always ready in handy cabinet. For holes up to 3½" diameter the "WALES-WAY" quick change method saves plenty of time on your job. The WALES FABRICATOR is the PRACTICAL single-hole punching equipment with plenty of reserve power for punching up to ¼" plate.

Immediate deliveries, and you may pay for this equipment out of profits if you wish. Let us tell you about this plan.

The NEW positive DUPLICATOR



This husky WALES DUPLICATOR increases the scope of your WALES FABRICATOR to make production runs both practical and profitable. It permits positive duplication of unlimited hole patterns from master templets to jig borer tolerances. The templet is secured in steel work table T slots of DUPLICATOR. Cam action clamps position work piece. Holes are located quickly and easily by a stylus type locater pin. Press gently and the hole is duplicated EXACTLY on the work piece. The WALES positive DUPLICATOR does a terrific job. Any man in your shop can handle it perfectly in a few minutes.

Send For Bulletin No. 14D

Get the complete story of the WALES Sheet Metal FABRICATOR with proof of performance. The facts about the positive DUPLICATOR are included. This is the type of equipment that merits your consideration NOW.

See the NEW WALES MOBILE FIELD UNIT

Outfitted with Fabricator, Duplicator, Tooling and equipment to show you, right at your door, the money making potential of the "WALES-WAY". Let us arrange for the Field Unit to visit YOU.

WALES Strippit CORPORATION

"...the Wales-Way is the PLUS-PROFIT way"

345 PAYNE AVE. — North Tonawanda, N.Y.

WALES-STRIPPIT OF CANADA LTD., HAMILTON, ONT.

If you're stuck with high costs...

think of your Kaiser Aluminum

LET YOUR Kaiser Aluminum Distributor free you from costly storage expenses. It's simple—just draw from his stock as you would from your own.

By using his warehouse, you can reduce your overhead through lower insurance and taxes, less accounting, less material damage and lower handling costs. You can also eliminate unnecessary metal-working equipment and reduce scrap handling because he can supply aluminum cut to your needs.

And you can rely on your Kaiser Aluminum Distributor to do everything possible to fill your emergency orders the minute you call!

In addition, he's had wide experience in the metals field and can give you expert advice and help on your manufacturing problems. He can specify the exact type of aluminum your product requires. He can suggest methods of using aluminum more economically. He can supply you with small quantities for experimental work.

All these services mean more profits for you because they lower your cost!

Take advantage of the personalized service offered you by your Kaiser Aluminum Distributor. Call him today!

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Nottingham Steel & Aluminum Company
Phone: Atlantic 1-5100
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Earle M. Jorgensen Co., Riverside 1761
DAVENPORT, IOWA, Phone: 3-1895
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Korhumel Steel & Aluminum Co.
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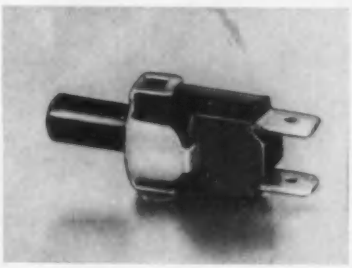
WICHITA, KANSAS, Amherst 7-1208—7-1209
General Metals, Inc.

constant force wiper mechanism is effected to afford service-free life of 500 hr min. Each pole can be conveniently adjusted in phase while the switch is operating. Approximate size is 1½ x 1½ x 6⅞ in. General Devices, Inc., P. O. Box 253, Princeton, N. J.

For more information—
Circle 60, inside back cover

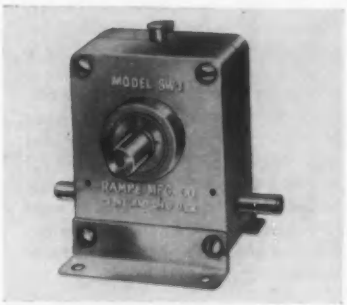


Momentary Contact Switches

These switches are said to be especially designed for turning on lights in refrigerators, automobiles, bathroom cabinets, kitchen cabinets, stoves, vending machines, freezers.

Four terminal styles are available: space-type, solder-type, screw-type, and with wire leads. Switches are suitable for mounting with nipple, snap fastener, or special plates made to individual specifications. Rating is ¼ amp, 250 v; ¾ amp, 125 v. Alcor Mfg. Co., 4444 W. Roosevelt Road, Dept. 21, Chicago 24, Ill.

For more information—
Circle 61, inside back cover



Speed Reducer

The case of this gear reduction unit, for use with fhp motors, is molded from polyester glass fiber and the gear is made of nylon. The worm is steel. They are available in seven sizes with speed reductions ranging from 5½:1

CONTINUED ON PAGE 226

HOW DOES GARRETT GIVE SUCH SERVICE?

What others may call impossible Garrett comes through as routine service. It seems as though they treat each order as the only one in their three plants. Everybody pitches in for service with the customer in mind.

If it is a stock item such as lock washers, flat washers, spring washers or hose clamps the order is usually on the way the same day. If it is stampings or assemblies Garrett engineers, production men and die makers team up to make their high-speed automatic equipment really hum . . . and your order is in your hands in half the time.

Want to be surprised by real service you can't beat? Next time send your order to Garrett for . . .

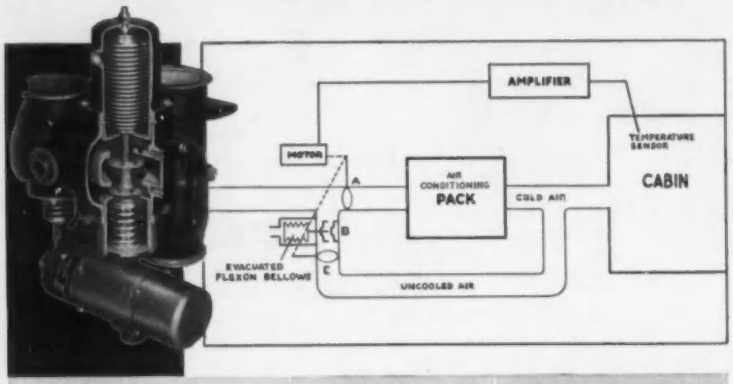
LOCK WASHERS
FLAT WASHERS
HOSE CLAMPS
SPRING WASHERS
STAMPINGS

Manufactured by
GEORGE K. GARRETT CO., Inc.
Philadelphia 34, Pa.

Garrett
OF PHILADELPHIA

FLEXON® BELLOWS *Design Briefs*

Flexon® Bellows Governs Complex Air Conditioner Air Flow Valve



HOW IT WORKS

Valves A and C are connected by linkage and operated by an electric motor controlled by a temperature sensor to maintain a balanced flow of air through the conditioner and the by-pass. When Valve A opens, Valve C closes and vice versa. The Flexon Bellows actuates Valve B to regulate total air flow.

FLEXON® OFFERS THE COMPLETE BELLOWS SERVICE

Flexonics Corporation manufactures a complete range of bellows and bellows assemblies in brass, bronze or stainless steel.

The Flexon Bellows Design Guide gives valuable application and design information. Write for your copy, today.

A Flexon Bellows is the heart of a mass flow valve manufactured by Stratos Division of Fairchild Engine and Airplane Corp., Long Island, N. Y.

Used in aircraft conditioning systems where upstream pressure varies over a wide range, the Stratos Mass Flow Valve is actually two valves in one body. Combining the features of a cabin temperature control valve and a conditioned flow regulator, its function is to maintain a constant flow of conditioned air to the aircraft cabin. Desired temperature is maintained by a balanced blending of cooled and uncooled air. The Flexon Bellows is used as an aneroid to maintain a constant volume of air regardless of atmospheric pressure. The schematic drawing above illustrates the operating principle.

The Flexon Bellows used in this valve design, like all Flexon Bellows, is cost engineered to meet the specific requirements of the job. To take advantage of this kind of service, send an outline of your requirements.

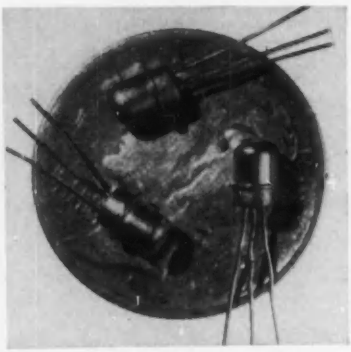
B-34

FLEXON® QUALITY
proved in service and backed by over 54 years manufacturing experience

Flexonics Corporation
FLEXON BELLOWS DIVISION
1351 S. THIRD AVENUE, MAYWOOD, ILLINOIS
FORMERLY CHICAGO METAL HOSE CORPORATION
Manufacturers of flexible metal hose and conduit, expansion joints, metallic bellows and assemblies of these components.
In Canada: Flexonics Corporation of Canada, Ltd., Brampton, Ontario

to 60:1. Shafts are furnished in two styles, solid and hollow. Rampe Mfg. Co., 14915 Woodworth Ave., Cleveland 10, Ohio.

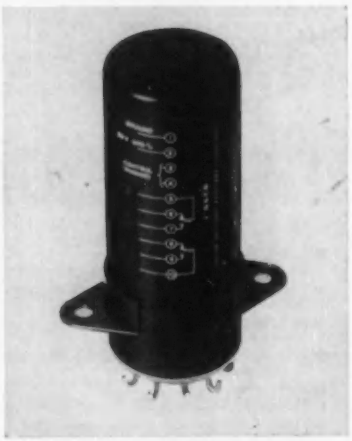
For more information—
Circle 62, inside back cover



Subminiature Transistor

More than 20 of these transistors can be placed on a dime. The device operates in the audio frequency range and performs the functions of larger size transistors. The unit is covered by a metal can which is hermetically sealed by welding. Philco Corp., Spring City, Pa.

For more information—
Circle 63, inside back cover



Magnetic Amplifier Relay

This miniature relay weighs 6 oz and was designed for use in circuits employing photocells, transistors or thermistors. It fits in an envelope measuring 1¼ x 2¾ in. The unit has a sensitivity of 80 microwatt for a zero to 5,000-ohm resistance source, de-

(Continued on page 269)

let OHMITE engineers "TEAM UP" with your engineers

IN SOLVING YOUR RESISTANCE PROBLEMS

Save valuable engineering time . . . team up with Ohmite to solve your resistance problems. Ohmite engineers are resistance specialists . . . they can quickly analyze your requirements and recommend the correct rheostats and resistors to fit your application. Years of experience in building dependable resistance units . . . complete design, development and production facilities . . . plus a long record of helping others to economically solve their resistance problems . . . are your assurance that Ohmite can help you. We invite you to submit your resistance problems to us.

OHMITE MANUFACTURING COMPANY, 3611 Howard Street, Skokie, Illinois (Suburb of Chicago)

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RHEOSTATS • RESISTORS • RELAYS • TAP SWITCHES • TANTALUM CAPACITORS

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AMRECON® *Relays*

HIGH QUALITY, ALL-PURPOSE RELAYS...
RUGGED, DEPENDABLE FOR LONG LIFE!

65 types in four stock models

Ohmite Amrecon relays have proven their exceptional ruggedness and long life in years of service. Now, four popular stock models—DOS, DOSY, DO, and CRU, in 65 different types—are available from stock.

Models DO and DOS fill many industrial needs for a compact, lightweight relay that handles power loads usually requiring much larger, heavier units. They are particularly adaptable to aircraft and mobile equipment where severe shock and vibration are encountered. The increased operating sensitivity of Model DOSY relay, equipped with twin coils, makes the DOSY adaptable to a wide range of electronic control circuits, such as plate circuit controls. At 115 VAC or 32 VDC, noninductive load, Models DOS and DOSY have contact ratings of 15 amp; Model DO, 10 amp; and Model CRU, 5 amp. Available in a wide range of coil operating voltages and contact combinations.

Current ratings up to 25 amp, AC or DC.
Also made-to-order models in many contact combinations and coil voltages.

HERMETICALLY SEALED OR DUST-PROTECTIVE ENCLOSURES

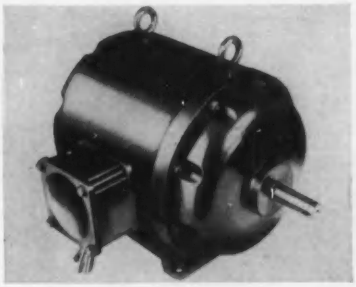
Be Right with
OHMITE®
RHEOSTATS • RESISTORS • RELAYS • TAP SWITCHES

SEND FOR CATALOG R-10

OHMITE MANUFACTURING COMPANY
3611 Howard Street, Skokie, Illinois
(Suburb of Chicago)

creasing to 100 microwatt for a 15,000-ohm source. It operates throughout an ambient temperature range of −55 C to 100 C. Liquidometer Corp., Skillman Ave. at 36 St., Long Island City 1, N. Y.

For more information—
Circle 64, inside back cover



Explosion-Proof Motor

A line of explosionproof motors, through NEMA frames 405 and 215, meets UL requirements for the three most common hazardous locations: gaseous, explosive dust and explosive grain dust. They are treated to resist moisture, dust and corrosive atmospheres and feature extra long flame paths at shaft and bracket fits and fully-sealed, pre-lubricated ball bearings. These motors are available in standard, geared, or variable speed models, with optional mountings to meet individual requirements. Sterling Electric Motors, Inc., 5401 Telegraph Road, Los Angeles 22, Calif.

For more information—
Circle 65, inside back cover

Very High Efficiency Air or Gas Filters

These filters were originally developed for AEC application. A number of standard sizes of filters, ranging from single units 8 x 8 in. in face area and 3 in. deep (for 30 cfm of air or gas per min) to filters 48 x 48 in. by 12 in. deep (for 5000 cfm).

Type No. 1, for service in noncorrosive atmospheres and for temperatures of 225 F and below, is made with a ½ in. plywood filter frame and may contain cellulose-asbestos paper, all-glass paper or other suitable media.

In order to accommodate large gas flow rates within a restricted volume, the paper is extensively pleated within

(Continued on page 272)

For functional parts and trim . . . pre-design planning with Nickeloid Metals pays off for sales-minded, cost-conscious manufacturers.

THESE FINE PRODUCTS WERE DESIGNED *AROUND* NICKELOID METALS

In the pre-design stage . . . before investing in tools and dies . . . consider pre-plated Nickeloid Metals. Take full advantage of their inspiring design potential and basic production savings, too. PRE-plated in uniform, quality-controlled finishes of chrome, nickel, copper or brass on base metals of steel, zinc, copper, brass and aluminum — Nickeloid Metals require no cleaning, plating, polishing. Just fabricate the parts and assemble. Eliminate 3 out of 5 basic manufacturing steps; save time, reduce costs, increase output.

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To protect the brilliantly finished surface during drawing and forming operations, and in handling, Nickeloid Metals are available with MAR-NOT — a protective covering that affords absolute protection until final assembly; then may be peeled off. **Write for full details.**

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Cleveland *Top Quality* Fasteners give you EXTRA Fastenability

Big word that means extra fast trouble-free driving them in where you want them

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Higher tensile too—these cold forged double-extruded cap screws made by Cleveland's own Kaufman Process now give you extra margins of strength.

No extra charge for any of these fasteners that help you put together a better product. Ship-at-once stocks of every kind and size we make! Ask your jobber for Cleveland Fasteners—or write us for latest stock list.

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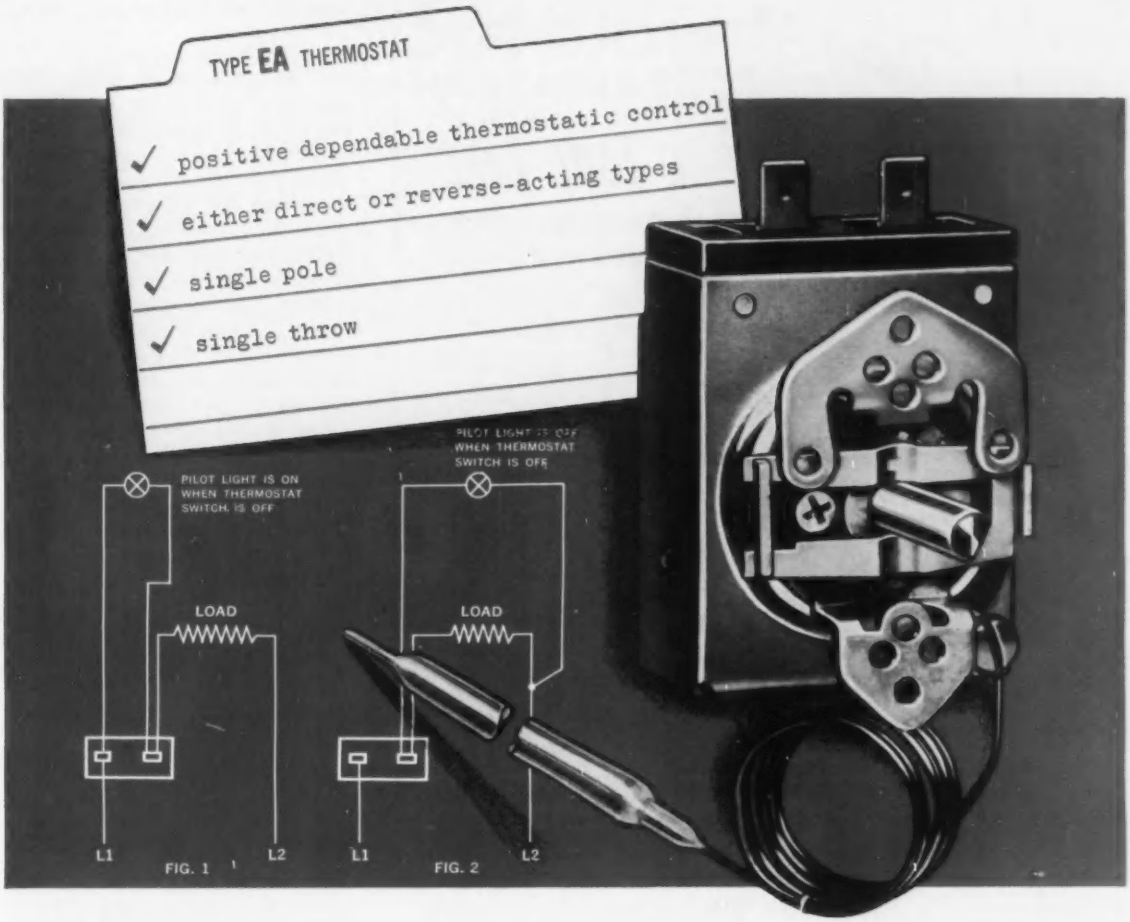
Kaufman DOUBLE EXTRUSION Process

The Cleveland Cap Screw Company

2936 East 79th Street, Cleveland 4, Ohio • VUlcan 3-3700 • TWX CV 42

At Design Engineering Show, Booth 324 • NAPA Inform-A-Show, Booth 237



Compactness and dependability

at

LOW COST

NEW EA THERMOSTATS fill the need for low-cost precision controls requiring rapid response to extremely close temperature differentials.

The same power element is incorporated which is used in heavy-duty Robertshaw controls. It can be supplied for application in liquid or air. The EA controls are of snap-action, single-line, double-break design. Silver contacts, stainless steel bellows are designed for sustained accuracy in service.

Robertshaw is the largest manufacturer of thermostats for commercial and industrial applications. For a full discussion of your specific needs, write today:

Robertshaw-Fulton CONTROLS COMPANY

Mr. Controls

Robertshaw Thermostat Division, Youngwood, Pa.
Robertshaw-Fulton Controls (Canada) Ltd., Toronto
(LARGEST MANUFACTURER OF THERMOSTATS FOR COMMERCIAL AND INDUSTRIAL APPLICATIONS.)

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Please send more information on your EA ☐

Also send information on a control for following application:_____

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HOW *Norgren* MICRO-FOG LUBRICATION

PROLONGS MACHINE TOOL LIFE

. . . Reduces wear on bearings - gears - chains - slides - ways - cams

Model 30-40-2S
32 Bearing Inch
1/3 pt. Oil Capacity

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Series S3406
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1 qt. Oil Capacity

Series X3400
32, 200, 300 Bearing Inch
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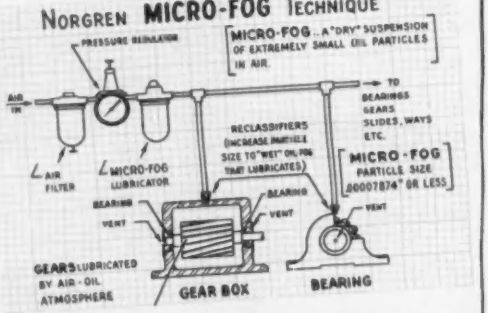
Series Y3400
32, 200, 300 Bearing Inch
4½ gal. Oil Capacity

Model 33AF-16
1000 Bearing Inch
2 gal. Oil Capacity



ONLY ONE LUBRICATOR NEEDED PER MACHINE Norgren MICRO-FOG can be uniformly distributed through a complex piping system to multiple lubrication points. One lubricator can completely lubricate all parts of a machine. Norgren has the most complete line of lubricators with maximum capacities up to 1000 bearing inches.

BETTER LUBRICATION Norgren MICRO-FOG completely covers the surfaces of bearings, gears, etc., automatically providing a continuous film of protective lubricant.

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LOWER BEARING TEMPERATURES Airborne Norgren MICRO-FOG maintains a lower operating temperature for machine tool parts — reducing wear, improving performance, increasing machine life.

VISIBLE OIL FLOW 360° visibility of oil flow simplifies adjustment of oil feed rate, and provides visual assurance that the lubricator is operating.

Without obligation, learn how Norgren MICRO-FOG can reduce costs, improve machine performance in your plant. Call your nearby Norgren Representative listed in your telephone directory—or **WRITE THE FACTORY FOR NEW No. 700 CATALOG.**

C. A. Norgren CO.

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Pioneer and Leader in Oil-Fog Lubrication Since 1930

the filter frame and the pleats held apart with corrugated separators. These may be of paper as in Type No. 1, but for the all-mineral filters they are customarily made of aluminum or stainless steel. All mineral filters, Types No. 2 and No. 3, are useful for temperatures up to 1000 F. In addition to high temperatures, the all-mineral filter is used for corrosive atmospheres.

When suitably mounted, each of the three filters is reportedly able to remove greater than 99.95 per cent of 0.3 micron dia. chemical smoke. Air flow resistance of the new filter is 1.0 in. of water gage at its rated flow of 250 cfm/sq ft filter face area.

The practical service life of these filters is said to have been as long as 2 or 3 yr. For most situations it has proved advantageous to protect the high efficiency filter against excess dust loadings by the use of prefilters, which remove the coarser particles (generally representing the bulk of the dust) and some of the finer particles, as well. Flanders Mill, Inc., Riverhead, N. Y.

For more information— Circle 66, inside back cover

Fhp 1550 Rpm Motor

An fhp motor for heating, ventilating, air conditioning, refrigeration equipment and appliances has a stator core frame that is die cast under very high pressure. By machining both stator core registers simultaneously, the registers are held concentric with each other and to bore to close tolerances. The end frames which are then set into these machined registers provide both positive bearing alignment and a uniform air gap to make the motor quiet in operation.

Motor shorts and grounds are elim-

(Continued on page 273)

inated through the use of thermosetting phenolic end-turn insulators. The extra tough case-hardened studs prevent the threads from stripping. Oil wicks are made of spun nylon.

The motor is of four-pole design, 1550 rpm, 115 or 230 v, 60 cps. It is also available in odd voltages and frequencies or in either open ventilated or totally enclosed construction. It develops 1/250 to 1/15 hp. The shaft is $\frac{5}{16}$ in. dia. There are 14 lead outlets. These motors are built of UL-approved materials. Redmond Co., Inc., Owosso, Mich.

For more information—
Circle 67, inside back cover

Electric Tachometer

This instrument is a hermetically sealed, remote indicating unit for engine speeds of 0 to 4000 rpm. The unit is mounted in a 2 in. dia case of $4\frac{1}{4}$ in. long. Weight is 0.9 lb. Burton Mfg. Co., Colorado Ave. at 26 St., Santa Monica, Calif.

For more information—
Circle 68, inside back cover

Molded Bumpers

These contour molded neoprene bumpers are designed for air and hydraulic cylinder shafts, as ejectors, lifters and kickers and also as shock absorbing rests and stops for elevating

(Continued on page 277)

Norgren

MICRO-FOG

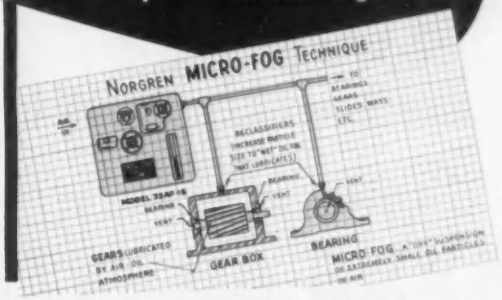
Model 33AF-16
Lubro-Control Unit

Easy to design into your machines—one lubricator does the job of many—provides controls to actuate an alarm system.

THE LATEST ADVANCEMENT IN CENTRALIZED LUBRICATION

. . . for up to 1000 bearing inches*

for
BEARINGS
GEARS
CHAINS
CAMS
SLIDES
WAYS
Other Machine Components



AUTOMATIC MICRO-FOG LUBRICATION—The 33AF-16 Unit automatically creates a finely divided air-borne oil fog which can be uniformly distributed through complex piping systems to multiple lubrication points.

LARGE LUBRICATING CAPACITY—A single unit can completely lubricate even the largest machines — up to 1000 bearing inches.

AUTOMATIC ALARM CONTROLS—Two pressure switches and a float-controlled switch are provided to automatically actuate an alarm system or controls when air pressure fails, when excessive pressure develops in the oil reservoir, or when the oil supply needs replenishing.

COMPACT, COMPLETE UNIT—Although only 12" x 11" x 9" in size, this lubricator contains all necessary controls plus a 2-gallon oil reservoir—enough oil for 12 hours lubrication at maximum MICRO-FOG output.

AUTOMATIC DRAIN FILTER—Protects entire equipment from abrasive and corrosive air line contaminants. Drains collected liquids automatically.

PRESSURE REGULATOR—Accurately regulates air pressure for most efficient lubrication.

VISUAL OIL FEED—Oil feed dome on front of unit provides a quick visual indication of proper operation of lubricator.

TWO AIR SUPPLY INLETS—Both are ½". One is at left side, one in back of unit. The most convenient inlet can be used, the other plugged.

FOUR MICRO-FOG OUTLETS—Three outlets are 1¼", one is 2" with a female tapered thread. One or more may be used.

AUXILIARY AIR TAKE-OFF—A ¼" take-off is provided in top of unit to supply air for pressure jet reclassifiers if required.

SOLENOID VALVE—Coordinates operation of the lubricator with starting and stopping of machine.

TWO ELECTRICAL INLETS—For ¾" conduit — conveniently located at left end and at back of unit lead to splash-proof terminal compartment. Either or both may be used.

Norgren CO.
C.A.

3428 So. Elati St., Englewood, Colo.

*For complete data on Norgren MICRO-FOG 33AF-16 Lubro-Control Unit, call your nearby Norgren Representative listed in your telephone directory—or WRITE THE FACTORY FOR BULLETIN 531.

Wherever Air is Used in Industry

IP

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for every application...

From bomber to baby-buggy, our 35 years of expert engineering skills can help you improve *your* product performance!

Add to these, our large-scale metal-working facilities, equipped with every modern means to make the *world's finest shafts!* Our new shot peening process guarantees finished shafts *proved up to 5 times tougher* than unpeened shafts! We will be happy to work with you on any problem that turns on a shaft.

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- Idler Shafts
- Gear Shafts
- Clutch Shafts
- Cam Shafts
- Transmission Shafts

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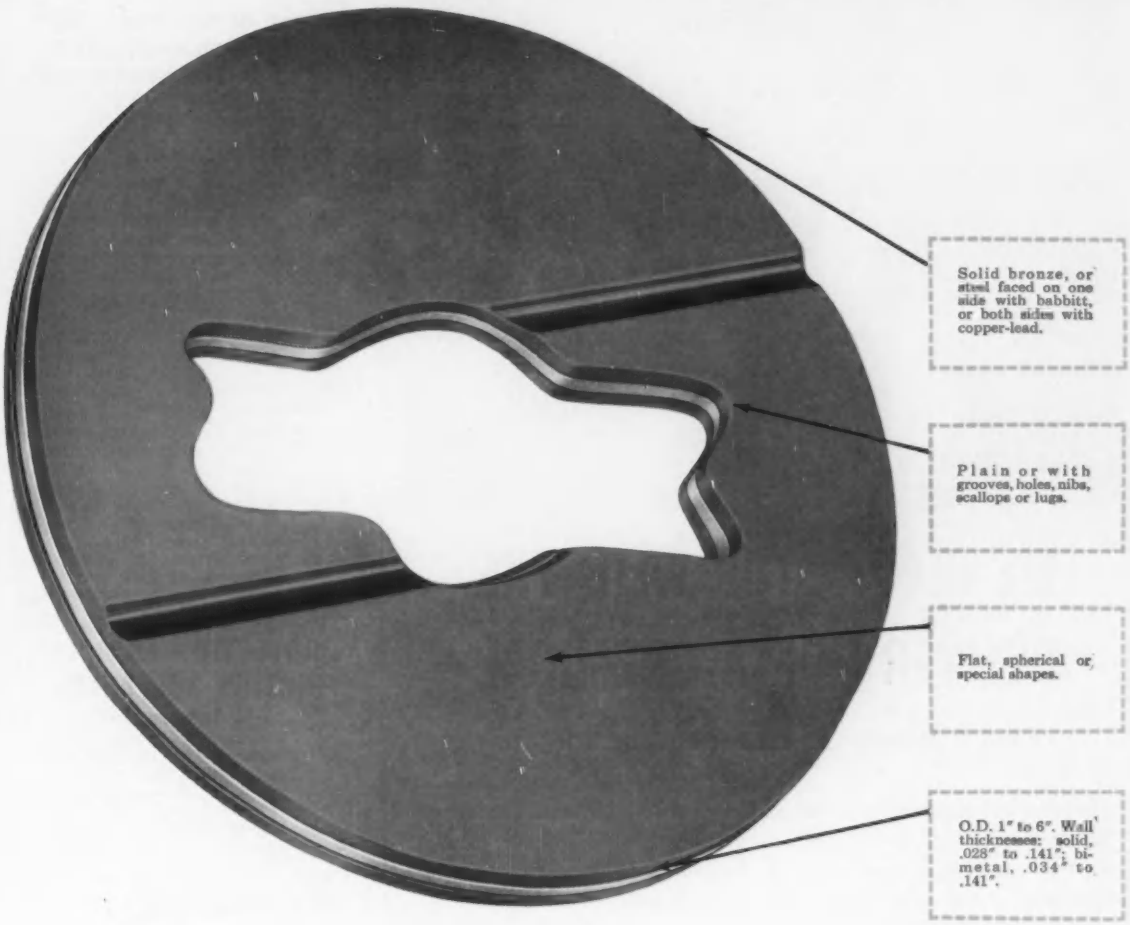
This illustrated folder will show you why U. S. AXLE is your best source for precision-made special shafts. Write for your copy today.

For a prompt quotation on a U. S. "Custom-Engineered" Shaft to meet your needs, send us your blueprints and specifications.

THE US AXLE COMPANY, INC.
Since 1920 • Pottstown, Pennsylvania


Solid bronze, or steel faced on one side with babbitt, or both sides with copper-lead.
Plain or with grooves, holes, nibs, scallops or lugs.
Flat, spherical or special shapes.
O.D. 1" to 6". Wall thicknesses: solid, .028" to .141"; bi-metal, .034" to .141".

Washers can have Two Bearing Surfaces

Our cold-rolled thrust washers can be given two faces of sintered copper-lead to do double duty. They have exceptional hardness for heavy duty. Coining of special lubrication grooves avoids costly machining. We meet your specifications. Large capacity. Complete engineering service. Address:

FEDERAL-MOGUL

DIVISION, Federal-Mogul-Bower Bearings, Inc.

11043 Shoemaker, Detroit 13, Michigan

BABBITT-LINED BEARINGS

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SPACER TUBES

COPPER-LEAD BEARINGS

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WE DON'T STOP WITH THE DELIVERY OF A CHEMICAL—

we put it to work and keep it working effectively

The chemical treatment of metals and metal parts—to prepare them for further processing, to protect them, to beautify them—has grown from a haphazard operation to a highly technical one. Supplying the chemical ingredients is a relatively simple job. Putting them to work and keeping them working effectively in your plant demands the skill of an experienced organization. We have that organization.

We supply not only the metal-treating chemicals, but also—free of charge—the technical and engineering service to keep them working at top efficiency. We furnish assistance in developing and installing the process, we maintain continuing inspection of the process and equipment if you so desire, we check samples of the processed metals in our Quality Control Laboratories—all these are part of the ACP service at your command.

That's why we say, "We don't stop with the delivery of a chemical—we put it to work and keep it working effectively." And we have been doing this for over 40 years. Write for a booklet describing ACP products and services.

Some of the many ACP processes and chemicals used in the treatment of metals

PAINT BONDING

Granodine® forms a phosphate coating base on iron and steel products—provides an excellent bond for paint, and greatly improves the corrosion resistance of the paint system.

Alodine® forms an amorphous film on aluminum which protects the metal and anchors the paint finish. Alodized aluminum meets service specifications.

Lithoform® promotes a good bond for paint on galvanized iron, zinc and cadmium plated surfaces. Also prevents any objectionable chemical reaction between applied paint film and the metal surface. One grade of Lithoform, in itself, provides excellent corrosion resistance on zinc and cadmium.

PROTECTION FOR FRICTION SURFACES

Thermoil-Granodine® forms a manganese iron phosphate surface which materially reduces wear and minimizes galling by eliminating metal-to-metal contact. It is particularly effective during break-in period of bearing surfaces.

RUSTPROOFING

Permadine®—a zinc phosphate coating chemical—forms a heavy oil-adsorptive crystalline coating on steel. Bonds paint or such rust-inhibiting oils as Granoleum®.

Thermoil-Granodine®—a manganese iron phosphate coating chemical—forms on steel a dense crystalline coating which, when oiled or painted inhibits corrosion.

IMPROVED DRAWING AND COLD FORMING

Granodraw® for steel, Granodraw SS for stainless, and Alodine® for aluminum for an integral coating with the base metal which facilitates the cold mechanical deformation of the metal, improves drawing characteristics and lengthens die life.

A pioneer in the development and servicing of metal treatment processes

AMERICAN CHEMICAL PAINT COMPANY Ambler 17, Pa.

DETROIT, MICHIGAN NILES, CALIFORNIA
WINDSOR, ONTARIO

CHEMICALS ACP PROCESSES

or horizontal traveling mechanisms. Core is of cold-rolled steel, drilled and tapped to size. Stilson Tool, Inc., 30231 Groesbeck Hwy, Roseville, Mich.

For more information—
Circle 69, inside back cover

Motor Winding Thermostat

A snap-acting, disc-type, hermetically sealed thermostat designed to be attached directly to the end-turns of large, integral motor windings prior to impregnation and baking interrupts the magnetic starter when the temperature build-up in windings is not recognized by the remotely located overload relay. This thermostat provides full running protection under all conditions of overheating in which the temperature rise is gradual. The device will withstand vacuum impregnating and baking at a maximum temperature of 500 F and is sealed with adequate insulation for 600 v. Metals & Controls Corp., Spencer Thermostat Div., Attleboro, Mass.

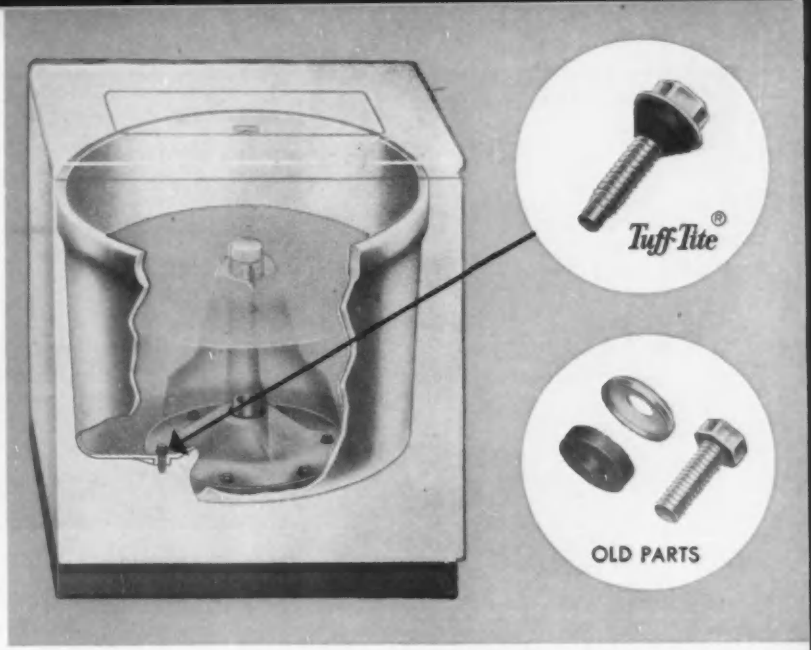
For more information—
Circle 70, inside back cover

Miniature Wafer Switch

These switches are available in both shorting and non-shorting types with from one to four poles per deck and two to thirty-two positions per deck. Up to six decks may be ganged. An easily adjusted stop limits switch rotation to less than the maximum number of positions if desired. Positive indexing, regardless of the number of decks used, is provided by two stainless steel ball bearings held in a circular, flat, stainless steel spring. Torque is from 3 to 5 in-lb for a single deck switch.

The switch measures 1¾ in. square and has a back-panel depth of 1 in.

(Continued on page 280)



Townsend *Tuff-Tite*® Fastener Gives Leakproof Fastening... Protects Enamel On Washer Tub

A large manufacturer of domestic washing machines has found the solution to leakproof fastening of tub to frame with Townsend Tuff-Tite fasteners. Previously, a three-piece fastener had been used—bolt, metal washer and flat neoprene washer.

Now, the one-piece Tuff-Tite brass bolt and washer with the conical assembled neoprene washer shown above is doing the job.

The result—positive leakproof assembly—superior protection from chipping the porcelain enamel—greater resistance to loosening from vibration. Assembly has been speeded and triple inventory eliminated.

This achievement is made possible by the design of all Tuff-Tite fasteners. They have an undercut in the washer head which controls and traps the neoprene when the fastener is tightened. The neoprene is forced into the hole and around the threads to provide a cushion which protects the surface and forms a water-tight and air-tight seal.

Tuff-Tite fasteners are available with many types of screw and bolt shanks and head styles. They are made of carbon, alloy, and stainless steel, aluminum, brass and other metals.

To learn more about how Tuff-Tite can give you leakproof surface protection with economy, use the coupon below.

The Fastening Authority

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COMPANY • ESTABLISHED 1816

NEW BRIGHTON, PENNSYLVANIA

Sales Offices in Principal Cities

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In Canada: *Parmenter & Bulloch Manufacturing Company, Ltd., Gananoque, Ontario*

TOWNSEND COMPANY
Post Office Box 237D
New Brighton, Pa.

Please send to me without obligation "Tuff-Tite" Bulletin TL-97.

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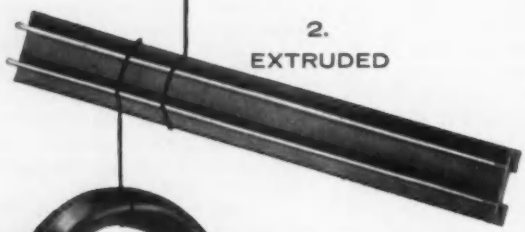
City_____ Zone_____ State_____

ACADIA

MEETS YOUR SYNTHETIC RUBBER NEEDS

BEST

OUT OF 3 WAYS!



And when there's another way to form synthetic rubber, you can be sure it will be available from Acadia!

Right now Acadia is precisely meeting all manner of rubber specifications. Very often Acadia helps users to find a better, less costly way.

For in addition to the complete choice of shape, size or method, Acadia offers its wide experience in developing special rubber properties. Here you get exactly the characteristics you want—*strength, compression-deflection, resistance to oil, age or what have you.* Here, too, is the remarkable Acadia SILICONE rubber that stays resilient at 100° *below zero,* or 500° above. It's available molded or extruded for gaskets, seals, "O" rings, washers, sheets, cut-parts and packings.

Would you like further information about Acadia synthetics for *your* product? A letter or postcard will bring an Acadia representative at your convenience.

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DIVISION OF WESTERN FELT WORKS

MANUFACTURERS AND CUTTERS OF WOOL FELT

THIS CLEVER, DEPENDABLE Electro-Pneumatic Timer Controls Intricate Work Cycles . . .

By means of this simple but astonishing unit, air pressure is distributed to air cylinders, air presses, air hammers, work feeders, clamping fixtures, chip blowers, work ejectors . . . each independent of the other as to start, duration, and end of cycle.

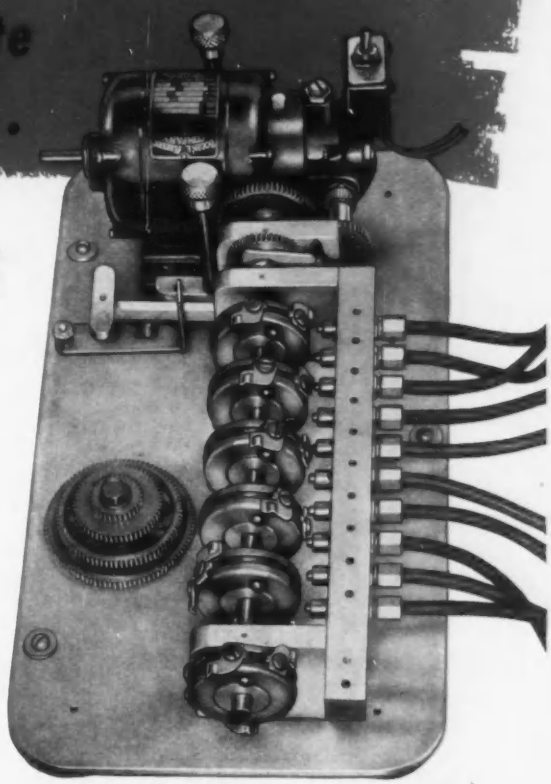
Here, indeed, is a big, easy step towards automation of many ticklish production jobs. With this timer, it's simple to hook up six, twelve or more air cylinders in numerous sequences from 2½ seconds to 33½ seconds duration. Cams mounted on the revolving shaft trip the miniature poppet valves, which in turn actuate the working valves and cylinders.

Normally, each of the six rotors carries two small cams, to charge and discharge a double-acting cylinder once in each complete cycle. Additional cams could be mounted on the rotor to actuate the cylinder more than once in each cycle, if desired.

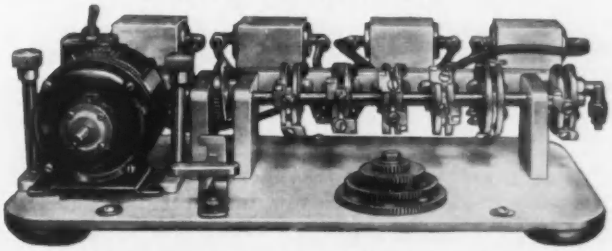
The duration of the complete cycle is controlled by the size of the gears on the rotor shaft and the motor shaft. 69 variations of speed are obtained with the ten quick-change gears furnished. Within the time required for one complete revolution of the shaft, an almost infinite variety of sequences can be made merely by adjusting the position and spacing of the 12 individual cams.

Meadmatic ¼" or ½" four-way valves are connected to the miniature poppet valves of the timer by flexible ¼" O. D. plastic hose, the valves themselves being located at any convenient distance from the timer. Continuous operation or single-cycle with push button starter, merely by moving lock-out lever.

Truly, this inexpensive unit opens up new possibilities for automation with a minimum of effort and investment, and the chance to save important production costs.



No. 6 Electro-Pneumatic Timer



Front View, showing hookup with four Meadmatic Valves

Write Factory or Nearest Mead Representative for Bulletin PE-56

Write for catalog of this and other timers and pneumatic cost-savers—or let our representative show you some of the possibilities. *(See Volume 111 Thomas' Register for nearest address, phone number.)*

Electro-Pneumatic Timer is a Cost-Saving product of

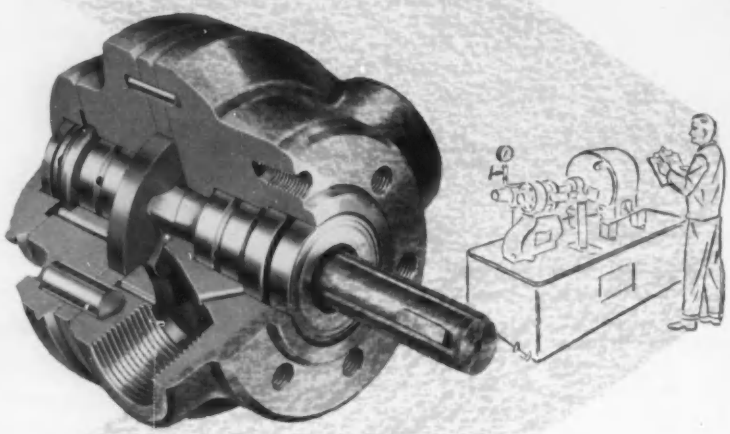
MEAD

SPECIALTIES COMPANY

4114 N. Knox Ave., Dept. PE-56, Chicago 41, Illinois

PATHFINDER IN AIR POWER AUTOMATION

Gerotor Hydraulic Pumps



give Higher Efficiency at Lower Operating Cost!

All Gerotor hydraulic pumps are recognized throughout industry for their outstanding design and performance. Heart of each unit is the exclusive *Gerotor* mechanism, both elements of which revolve in the same direction at relative low speed. This results in *longer life, less slippage, less wear,* a *smoother,* more *uniform flow.* In your plant or in your product—a GEROTOR pump means *higher efficiency* at *lower operating cost.*

Due to modern production facilities, GEROTOR can produce special pump designs in *quantities* on an economical basis. Whatever your hydraulic pump problems, bring them to GEROTOR.

Free literature available . . . *write:*

GEROTOR
MAY CORPORATION

MANUFACTURERS OF—

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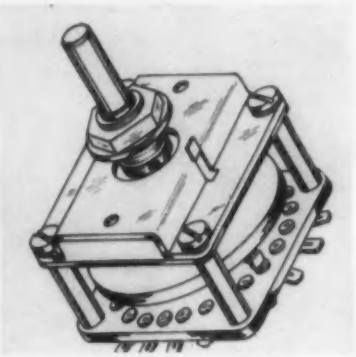


for the first deck, plus $\frac{3}{8}$ in. depth for each additional deck. The self-cleaning, self-aligning contact arms with individual spring action provide a uniformly low contact resistance of 0.0015 ohm or less. Solid silver alloy is used for all contacts, arms, and collector rings. Nominal contact breaking capacity is 5 amp at 125 v, ac. Shallcross Mfg. Co., Collingdale, Pa.

For more information—
Circle 71, inside back cover

Subminiature Switch

This switch has a current-carrying capacity of 10 amp at 115 or 230 v, ac, or 28 v, dc, inductive load. It is capable of operating in temperatures as high as 350 F and as low as −100 F in controlled atmosphere. Acro Mfg. Co., Columbus 16, Ohio.

For more information—
Circle 72, inside back cover

Iron Powder Spur Gears

AGMA commercial Class 4 and precision Class 1 spur gears are now made from pure electrolytic iron powder. Physical properties of most production steels are obtained. Gears up to 1 sq in. in cross-section can be produced. Supermet Div., Globe Industries, Inc., 1466 Cincinnati St., Dayton 8, Ohio.

For more information—
Circle 73, inside back cover

Connector with Hermetic Seal

Available in 51 contacts, this connector's pin contacts are hermetically sealed in a stainless steel receptacle

(Continued on page 281)

shell. Socket contacts in the plug are spring temper phosphor bronze and gold plated.

The plug shell is anodized aluminum and has a mineral-filled melamine insert. When the connector is engaged, an O-ring seals the mating surfaces of the receptacle and socket. Six polarizing key positions are available. DeJur-Amsco Corp., 45-01 Northern Blvd., Long Island City 1, N. Y.

For more information—
Circle 74, inside back cover

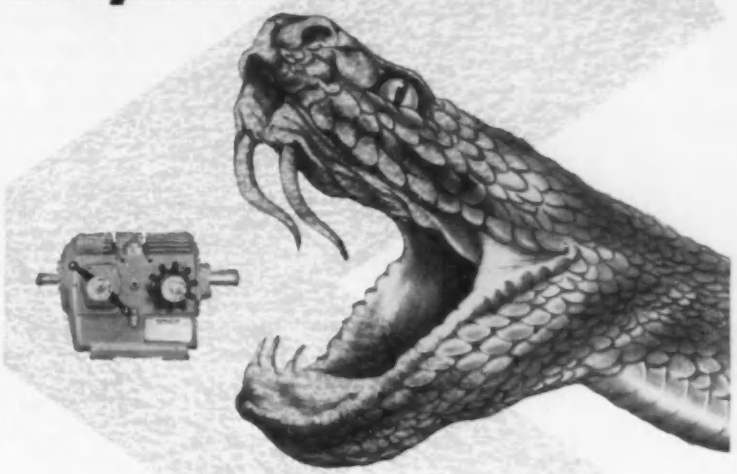
Adjustable High-Temperature Thermostat

This thermostat has two ranges, one from 600 to 1900 F, the other (for special applications) from 600 to 2400 F. It can be used, optionally for heat-holding or as an automatic shut-off device when connected to a relay. A low-cost accurate pyrometer can be incorporated with this unit if desired.

The device consists of a sensing tube approximately 10½ in. long, with a sensitive area of approximately 5 in.

(Continued on page 285)

We wore out 110,000 Rattlesnakes



Have you ever been awed by the rapidity with which a rattler strikes and recoils? You should be! Old "diamond-back" can lash out and reverse himself in about 1/10th of a second. There's one catch—he wears out after a second or so of continuous activity.

Rapid Reversing

can be fatiguing for machinery as well as rattlesnakes, but . . . for the record, we reversed a GEROTOR VARIABLE SPEED HYDRAULIC TRANSMISSION (under load) over a million times—continuously at a rate of 22 times per minute—without the slightest sign of wear to the Gerotor Transmission.

If your operation demands rapid reversing, infinitely variable speeds, constant or variable torque and horsepower—all with positive overload protection—check on the new GEROTOR VARIABLE SPEED HYDRAULIC TRANSMISSION. *Write*:

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ROCKFORD

FIRST

Using a new type friction material of recent development, ROCKFORD was the FIRST to engineer these new materials into MORLIFE Clutches and Clutch Plates. They reduce clutch size and engaging pressure, operate longer without adjustment or plate replacement — and avoid down-time caused by burned or warped plates in heavy duty tractors, trucks, tanks, cranes, power units, shovels, bulldozers, earth movers and other heavy duty machines.

MORLIFE* CLUTCHES and CLUTCH PLATES

*TRADE MARK

"MORLIFE clutch has gone 851 hours without slipping or adjustment."

"MORLIFE clutches last 950 hours longer, without adjustment."

"MORLIFE clutch needs adjustment once a month, instead of daily."

"MORLIFE requires lighter handle pull and one tenth the adjustments."

"MORLIFE clutch going strong after 1695 hours, working in sand."

"MORLIFE pulls harder and lasts six to ten times longer."

400% MORE LIFE

100% MORE TORQUE

50% MORE HEAT RESISTANCE

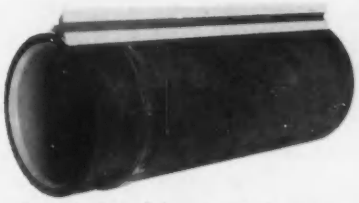
Before you approve specifications for your next models, it will pay you to investigate how MORLIFE Clutches will add to the service life of your product and reduce the number of stops for adjustments and repairs. It also will pay you to recheck specifications for your present models. For information covering operating characteristics, write Department E.

ROCKFORD Clutch Division BORG-WARNER

209 Catherine Street, Rockford, Illinois, U.S.A.

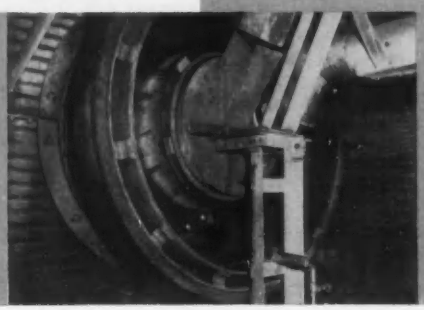
CLUTCHES

How designers use Porcelain Enamel to reduce costs



Porcelain Enameled pump cylinder wears longer and costs less than special alloys.

Pump plunger employed in oil field operations. Porcelain Enamel is more durable, reduces field service.



Spout for rotating dryer resists corrosion, abrasion and thermal shock because it is Porcelain Enamel.

Porcelain Enamel has proved to be an effective aid to designers in reducing costs. In a variety of ways, its unique properties are employed to effect savings in manufacturing and materials expense.

REPLACES COSTLY MATERIALS. Porcelain Enamel provides a non-porous, inorganic, glass-hard surface that makes it ideal for service where corrosion, abrasion and/or high temperatures prevail. Consequently, Porcelain Enamel can frequently replace costly high alloy or other metals.

REDUCES WEIGHT. The intimate fusing of the inorganic coating to the base metal materially increases the strength and rigidity of the product, thereby permitting weight-reduction in many of its applications. Its thermal-shock resistance makes thinner sections possible.

REDUCES FIELD SERVICE. A very practical advantage provided by Porcelain Enamel is reduction in field service. Where conditions of rust, corrosion, abrasion, high temperatures or thermal shock prevail, Porcelain Enamel resists attacks that would otherwise call for repairs and field service to the equipment. This not only saves money for the manufacturer, but also can be used as a powerful sales advantage.

Are you interested in knowing more about these benefits provided by Porcelain Enamel? We'll be glad to help you get the specific information you want. Let us know your problem, and we'll put you in touch with Porcelain Enamel Manufacturers, qualified to advise you.

PORCELAIN ENAMEL
PORCELAIN ENAMEL INSTITUTE, INC.

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(type of product)

Name_____

Company_____

Address_____

★ Control Components Digest ★

News and notes on resistors, rheostats, relays, motor controls, dimmers and other control components

SYLVANIA'S SOFT BLUE MERCURY VAPOR LAMPS are seen on many modern thoroughfares. Integral Ward Leonard resistor in each lamp contributes to reliable operation.

Improved mercury-lamp design features sealed-in resistor

Seal it in and forget it, for the lamp's life of 6000 hours plus!

That's the way engineers at Sylvania Electric Products Inc., Salem, Mass., treat the current-limiting resistors in their modern, improved mercury-vapor lamps.

And, naturally, for the heavy-duty, heat-, moisture- and ultra-violet-proof starting resistors, to be sealed up in these lamps, Sylvania engineers chose Ward Leonard Vitrohms.

These rugged resistors not only take the temperatures (to 750°F), but are immune to the heavy vibration encountered on or near bridges, ramps, railroad crossings or heavily-traveled highways.

Why not let a Ward Leonard engineer show you how Vitrohms can solve your resistor problem. Write today for complete information.

NEW MINISTRIP RESISTOR

New miniature power resistor

A new 20-watt Ward Leonard "Ministrip" resistor is now available.

Recommended where space is limited, but where no sacrifice can be made in quality, the new resistor features low, built-in mounting brackets (2-5/16 in. between centers) and an oval-shaped core for maximum strength.

Stock resistance values to 50,000 ohms; 5% tolerance.

Failure-free parts key to system reliability

Roughly speaking (and skipping a lot of mathematical subtleties) if you double the number of parts in a complex system—other things being the same—you'll cut in half its life expectancy.

The modern trend is toward more and more complex jobs for electrical and electronic gear. Doubling—and more—the number of parts goes on all the time. And yet it's vitally important that overall system reliability not be impaired.

That's why at Ward Leonard you'll find such painstaking attention devoted to increasing the reliability of our products. From incoming raw material to finished part, our careful attention to every phase of production and every inspection and test assures you of a product you can count on in *your* system.

CHECKING CONTACT PRESSURE on a Ward Leonard relay—one of the many 100% inspections and tests that assure its final quality.

USS FORRESTAL. Photo courtesy Newport News Shipbuilding and Dry Dock Company.

MAG-A-TROL for USS FORRESTAL

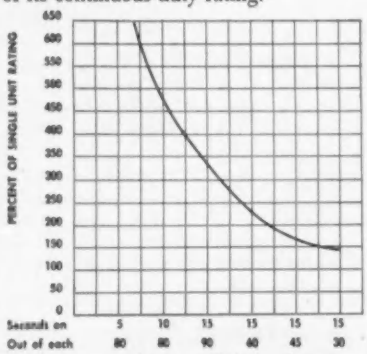
Precision-controlled lights guide pilots to the flight deck of the USS Forrestal, largest aircraft carrier.

The new carrier uses Ward Leonard magnetic-amplifier-type dimmers to insure correct light intensity on the flight deck at all times.

Besides the Forrestal's magnetic amplifier dimmers, Ward Leonard makes *all* types of lighting controls (autotransformer, reactance and resistance) for fluorescent or incandescent lamps.

Design aid for intermittent duty

A power resistor used only intermittently may be used at wattages in excess of its continuous-duty rating.



The curve above will help designers figure allowable dissipation increases for Ward Leonard Vitrohm and Ribflex resistors for various duty cycles. Assumed maximum temperature rise: 375°C; resistor spacing: 2½ in. This is one of many useful curves contained in our 64-page Catalog #15—ask for it today. 6.7

WARD LEONARD ELECTRIC COMPANY
63 SOUTH ST., MOUNT VERNON, N. Y.
Result-Engineered Controls Since 1892
RESISTORS · RHEOSTATS · RELAYS · CONTROLS · DIMMERS

This sensing tube is connected to a microswitch rated at 15 amp, 125 v, ac. A control panel with a pointer and scale showing the complete range of the thermostat is linked to the microswitch.

Accuracy is from ¼ to ½ per cent of full range. The temperature sensing element is completely mechanical and not affected by vibration, voltage fluctuations or stray magnetic fields. Dept. 15, Franklin Dales Co., 180 E. Mill St., Akron, Ohio.

For more information—
Circle 75, inside back cover

Pushbutton and Selector Switches

A line of explosionproof and dust-tight switch stations is available in surface mounting types for control circuits of 600 v, ac, max, for hazardous locations of Class 1, Groups C and D. Both standard duty and heavy duty types are furnished in a variety of single and two element stations—single or double pushbutton, single selector switch, or single pushbutton and selector switch units. They are offered in either button-operated or rocker arm-actuated mechanisms. Russel & Stoll Co., Inc., 125 Barclay St., New York 7, N. Y.

For more information—
Circle 76, inside back cover

Multiple Passage Rotary Joint

This joint contains four separate rotating passages; the large or outside passage operating on a different center of rotation than the inner rotating members, thereby compensating for roll eccentricity. This eliminates any

(Continued on page 288)

RECOMMENDED
CHAIN DRIVE POSITIONS

Fig. 1
Fig. 2
Fig. 3
Fig. 4
Fig. 5
Fig. 6
Fig. 7
Fig. 8
Fig. 9
Fig. 10

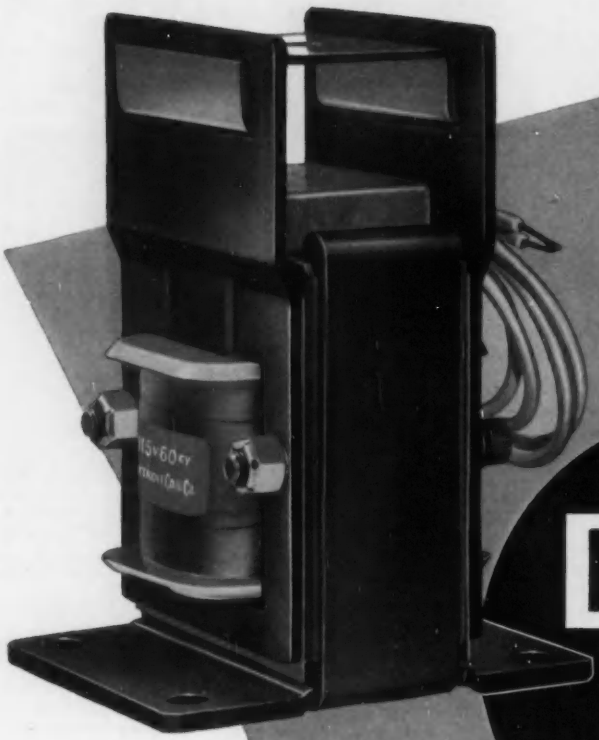
Illustrated here are several chain drive positions. Figures 1 to 5 are using a horizontal center line and slack strand is preferably on lower side. Figures 6 to 9 are vertical drives. Verticals, if possible, should be placed slightly off the vertical plane. Figures 1 to 4 and 7 and 9 are considered good practice. Idler sprockets as in figure 10 take up chain slack where it is not possible to use adjustable centers. Idler sprockets should be applied against the slack side of chain as near as possible to the fastest moving sprocket.

FREE TEXT! ACME's catalog is filled with chain facts, valuable data and tables that enlighten and save you time. Full table of sizes, strengths and list prices of cable and roller chain included. FREE upon request to engineers and designers. Write ACME CHAIN CORP., Dept. ID, Holyoke, Mass.

ACME chains and sprockets are of unexcelled quality . . . available from distributors all over the U.S.A. and Canada. Contact yours, or write directly to us.

Telephone: JE 2-9458

Acme Chain Corporation
HOLYOKE
MASSACHUSETTS

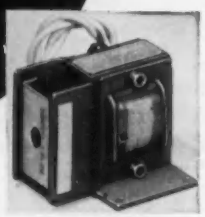


- Up to 30 pounds force. Push or pull.
- Full one inch stroke available.
- Decco shock-mounted for long life.
- High efficiency—silicon steel laminations.
- High moisture resistance.
- Shock absorbing bumpers cushion stroke.

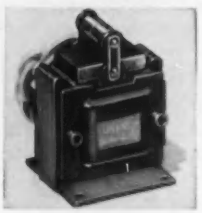
Decco

SERIES 50

INDUSTRIAL SOLENOIDS



Your choice of mounts



Push or pull types

Direct current solenoids

Decco's Series 50 offers more power—longer stroke with the same dependable quality and performance that has made Decco the top name in industrial solenoids.

There is a Decco solenoid for every requirement. Built to give better service for a longer time. Solenoids engineered and modified to your requirements. Let us discuss your problems.

For complete information write—

Decco SOLENOIDS THE HEART OF DEPENDABLE AUTOMATION EQUIPMENT

DETROIT COIL COMPANY

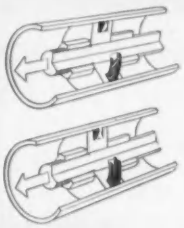
2435 HILTON ROAD, FERNDALE 20, MICHIGAN

problem:

save money with a seal that needs only 60-100 micro-inch groove finish to replace O-rings that need 10-20.

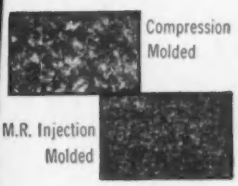
new answer:

minnesota rubber's money-saving new



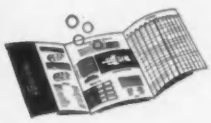
Why New Design Seals Better

QUAD RINGS eliminate "spiral twist", a common cause of packing failure. At any pressure, less squeeze is required with QUAD RINGS than with O-rings. Truly effective sealing even for pressures as low as 0-5 psi. QUAD RINGS also give a positive seal under high vacuum. The 4-lip sealing surfaces reduce breakout and running friction—giving longer life. Seal perfectly even with a rougher groove finish.



Why Minnesota Rubber Seals Last Longer

QUAD RINGS are injection molded by exclusive Minnesota Rubber process. Result is increased resistance to abrasions and chemical actions due to unequalled high density. Evidence of greater density is shown here in cross sections of Standard Buna N compound, .027″ x .019″, magnified 240 diameters by University of Minnesota.



Free Samples and Data

Free samples of QUAD RINGS are available together with a descriptive brochure with technical information and installation data. QUAD RINGS are the result of intensive research and field testing. Made to closest possible dimensional tolerances. We urge you to inquire about this revolutionary new seal today.

minnesota rubber and gasket company

Originators of modern rubber injection molding

Dept. 203, 3630 Wooddale Ave., Minneapolis 16, Minn. Phone: WEst 9-6781

PARTS LAST LONGER ... if they're centrifugally cast by the Shenango process. Tougher parts because of finer, pressure-dense grain, greater strength, better elongation and freedom from sand inclusions and blow holes. There's minimum waste, less machining. The large bronze liner and seat ring shown here are typical of various parts, large and small, ferrous and non-ferrous, regularly produced in Shenango's modern plant. Informative bulletins give all the facts. Write to: Shenango-Penn Mold Company, Centrifugal Castings Division, Dover, Ohio.
How SHENANGO CENTRIFUGAL CASTINGS pay off!
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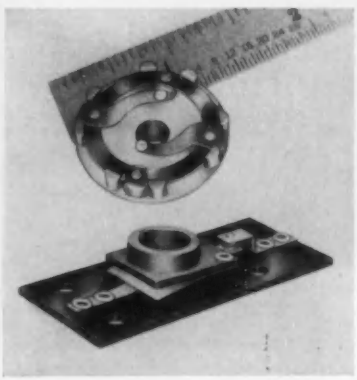
binding action between rotating members.

All rotating members can be easily removed and the variation in length tolerance can be as much as 1 to 1¼ in. This variable length of each rotating member (which is stainless steel tubing) does not have to be held to any close tolerance. Seals are inserted in accordance with the service requirements. Rotherm Engineering Co., Inc., 7280 W. Devon Ave., Chicago 31, Ill.

For more information—
Circle 77, inside back cover



Miniature Speed Control

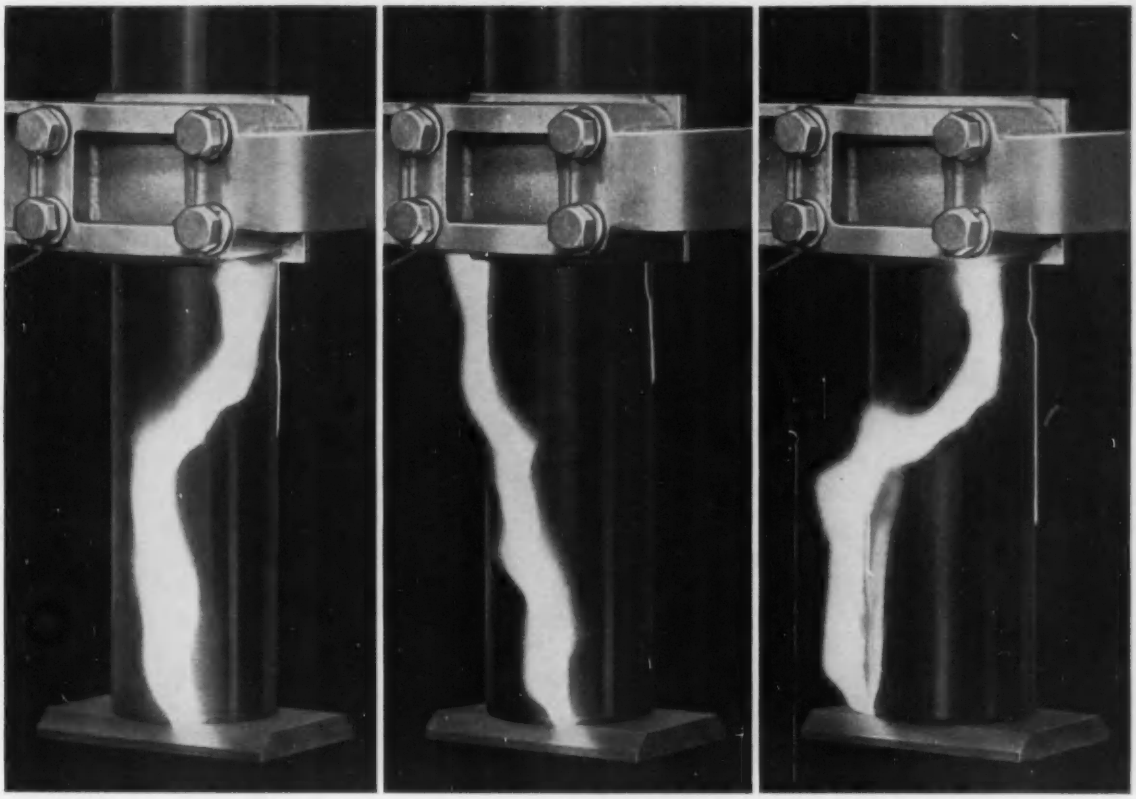
This new miniature device measures 1⅛ in. dia. It is said to possess an accuracy of ¼ of 1 per cent, and is rated for a uniform operation life of 1 to 1.5 million operations. Torq Engineered Products, Inc., Interstate St., Bedford, Ohio.

For more information—
Circle 78, inside back cover

Oil Fog Lubricator

This unit automatically creates a finely divided air-borne oil fog which can lubricate up to 1000 bearing-inches. Two pressure switches and

(Continued on page 292)



Unusual air dielectric test is only one of the host of rigorous tests continually carried out by National to give industry better insulating materials.

THE LATEST NEWS ON ELECTRICAL INSULATION

Three new PHENOLITE® electrical laminates by NATIONAL feature superior dimensional stability, exceptional flame retardance, unusually low cold flow.

Just when designers need them most, from National's Research Laboratory come tested answers to three of the electrical industry's stubbornest insulation problems.

Moisture resistant and dimensionally stable PHENOLITE epoxy resin and glass base laminate G-10-865 meets MIL-P-18177 Specification for critical electrical and electronic applications.

Flame retardant PHENOLITE Y-2500, used for arc chutes, tap changer switches, switchgear insulating barriers and supporting members, refuses to burn—has excellent arc resistance.

Low cold flow is the outstanding property of PHENOLITE E-2040 for radio and TV parts. Other features are low moisture absorption, good dielectric strength, and ease of hot punching and shearing.

If you have an electrical insulating problem—for power or electronic applications—bring it to National. Our staff of Applications Engineers will help you find the right answer in one of the many grades of versatile PHENOLITE. If you want more details of these three new PHENOLITE grades, write for technical bulletins. Address Department H-5.

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"I offer better performance cheaper—because of my superior ability to form an effective seal even though the surface to which I'm applied may have minor irregularities.
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"Costwise I'm a big money saver, as most gasket requirements can be cut from sheet stock—no expense of molded-on skin.
"My unique closed cellular structure will not absorb oxygen, moisture, dust, dirt—even at cut edges—eliminates need for special coating or molded-on skin.
"There's no restriction on my outline of shapes and I can be cut to any size.
"What's more, my inert nitrogen-filled cells offer greater cushioning and resiliency than other soft rubber materials."
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Write for information as to how you can get better performance cheaper with Rubatex.

GREAT AMERICAN INDUSTRIES, INC.
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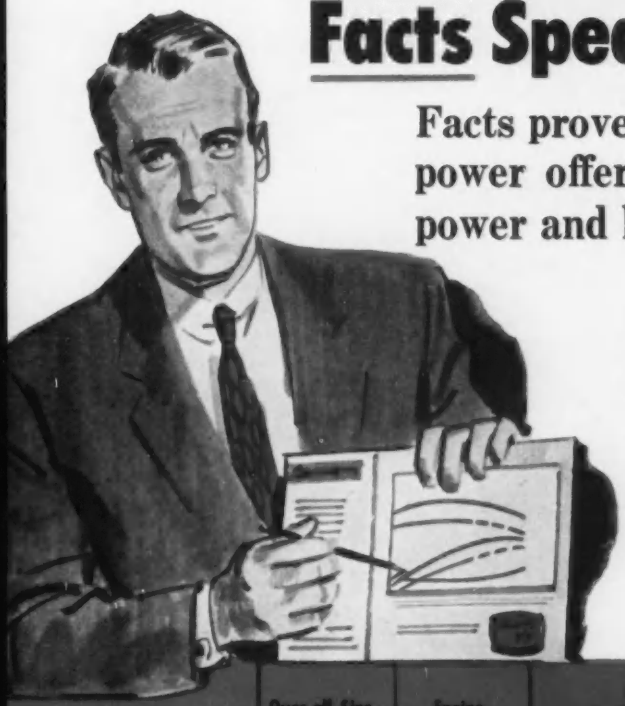


Facts Speak for Themselves

Facts prove Chrysler modern V-8 industrial power offers greater adaptability, greater power and higher mechanical efficiency

Size, speed range, horsepower, torque and efficiency . . . these are the most important considerations in selecting power for any equipment. Like every component part, the engine must be judged on the facts.

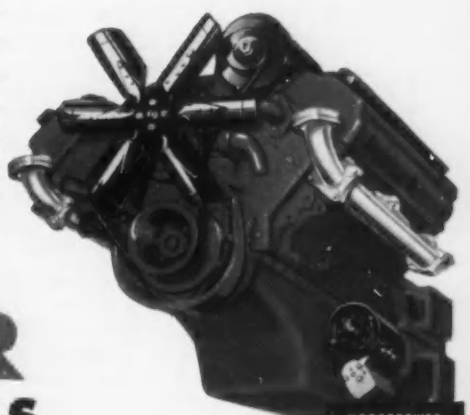
The Chrysler Industrial Model Ind. 56 V-8 Engine and a competitive engine of virtually the same piston displacement, permit a fair comparison and serve as a good example of the superior performance you may expect from Chrysler Pedigreed Power.

	Over-all Size—Power Unit	Engine Speed Range	Horsepower Available Throughout Speed Range	Torque Available Throughout Speed Range	Piston Speed at 2000 RPM
Chrysler Ind. 56 V-8 Industrial Engine—331 cubic inch displacement	34¾" width 49⅛" length 45½" height	800 to 3000 continuous rpm	92 h.p. at 1600 rpm 116 h.p. at 2000 rpm 138 h.p. at 2400 rpm	302 lb/ft at 1600 rpm 306 lb/ft at 2000 rpm 303 lb/ft at 2400 rpm	1210 feet per minute
Competitive Engine—330 cubic inch displacement	27⅞" width 51$^{13}/_{32}$" length 46$^{13}/_{16}$" height	600 to 2400 continuous rpm	76 h.p. at 1600 rpm 91 h.p. at 2000 rpm 104 h.p. at 2400 rpm	248 lb/ft at 1600 rpm 240 lb/ft at 2000 rpm 230 lb/ft at 2400 rpm	1450 feet per minute
Chrysler Advantage	**less length and height**	**22% greater speed range**	**21% greater h.p. at 1600 rpm 28% greater h.p. at 2000 rpm 32% greater h.p. at 2400 rpm**	**21% greater torque at 1600 rpm 28% greater torque at 2000 rpm 32% greater torque at 2400 rpm**	**16.5% less piston speed at any comparable engine speed**

The Chrysler Ind. 56 V-8 Engine offers greater power, greater flexibility of operation, higher mechanical efficiency, and smaller over-all size. These advantages—*plus* an appreciable savings in the lower initial cost of Chrysler Industrial V-8 Engines—add up to power you can't beat.

All Chrysler Industrial Engines—230 to 413 cubic inch displacement—offer money-saving, money-making advantages. Each can be equipped for use with gasoline, natural or propane fuels. A Chrysler Industrial Engine Dealer will be glad to help you. Find him in the yellow pages of your phone book, or write direct for detailed information: **Dept. 35, Industrial Engine Division, Chrysler Corporation, Trenton, Michigan.**

Chrysler Ind. 56 Engine—331 cubic inch displacement.



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INDUSTRIAL ENGINE DIVISION • CHRYSLER CORPORATION

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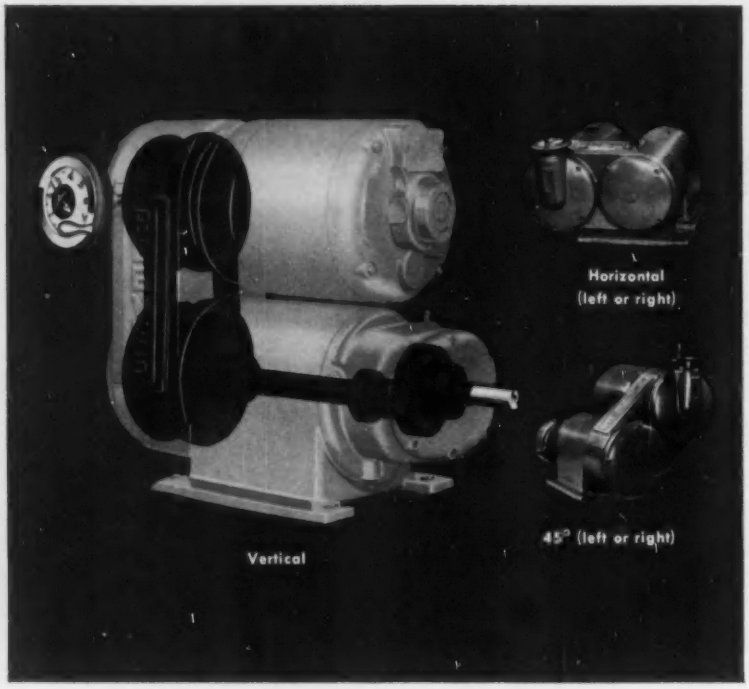
Whatever your product–Chrysler will work with you to power it!

Variable Speed – Styled For Compact Machine Designs



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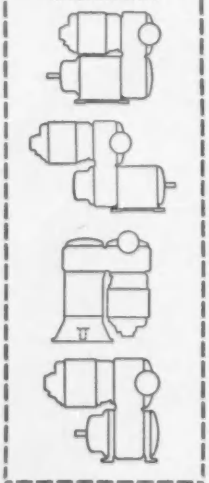
FRACTIONAL *Vari-Speed* MOTODRIVE

WHERE DO YOU NEED THE OUTPUT SHAFT?

Motor side, control side, or vertical down



▶ REEVES fractional hp. Motodrive is a complete power package, engineered in over 100 assemblies to fit wherever your design calls for variable speed.

Choose from vertical, 45° or horizontal models in ¼ to 1 hp. . . . get stepless accurate speeds—within a 2:1 to 10:1 range—from as low as 3 rpm to a maximum of 4660 rpm.

Available in standard, weather resistant, totally enclosed or splash-proof enclosures; full range of manual or automatic controls.

REEVES Motodrive—the *right* speed for *every* need . . . in *any* place.

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REEVES DIVISION • COLUMBUS, INDIANA
RELIANCE ELECTRIC AND ENGINEERING CO.

a float-controlled switch are provided for connection to a control panel, if desired, to actuate an automatic alarm system or controls when air pressure fails, when excessive pressure develops in the oil reservoir, or when the oil supply needs replenishing.

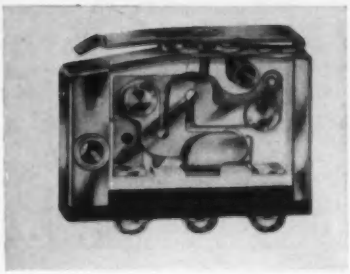
The device measures 12 x 11 x 9 in. It contains all necessary controls plus a 2 gal oil reservoir. C. A. Norgren Co., 3499 So. Elati, Englewood, Colo.

For more information—
Circle 79, inside back cover

Swivel Caster That Locks

This swivel caster becomes rigid by turning a special pin. When the pin is moved, a cam-operated plunger enters a special notch in the yoke base of the caster rig and sets the caster in a rigid position. Rapids-Standard Co., Inc., 342 Rapistan Bldg., Grand Rapids 2, Mich.

For more information—
Circle 80, inside back cover



Hermetically Sealed Switch

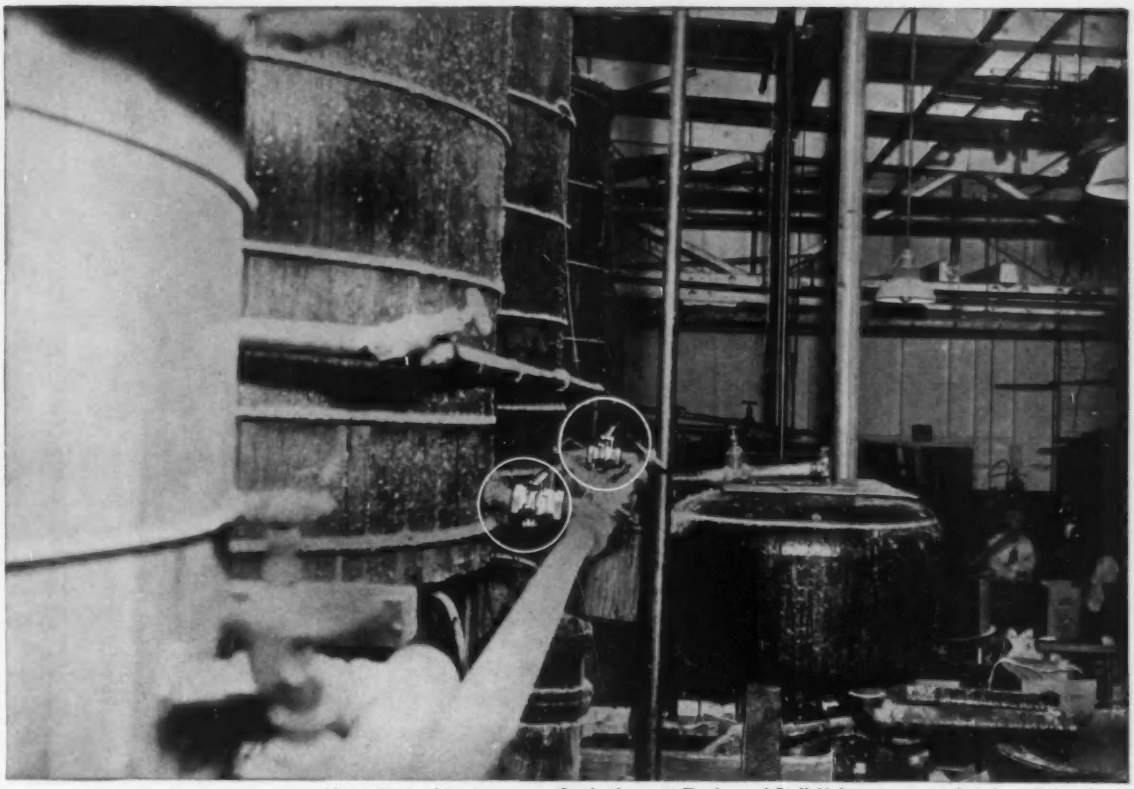
A sine switch is a snap-action unit that has an actuating arm which operates a wave-type metal diaphragm. This arm is locked to eliminate rotating. The switch is sealed in a controlled atmosphere and internally designed to provide maximum clearance between current-carrying parts. Spencer Thermostat Div., Metals & Controls Corp., 34 Forest St., Attleboro, Mass.

For more information—
Circle 81, inside back cover

Six-Digit Counter

An electrical impulse counter with instantaneous electrical reset is suitable for flush mounting, measuring $1\frac{3}{8}$ x $2\frac{3}{8}$ x $4\frac{1}{2}$ in. The standard six-

(Continued on page 295)



Not a Drop of Leakage . . . that's the way Rockwood Ball Valves prevent clogging of the pipes attached to these shellac-cutting tanks.

No leaking, no maintenance

. . . no wonder — they're Rockwood Ball Valves!

Rockwood Ball Valves give you leakproof, trouble-free performance! The Parks Company of Fall River, Massachusetts, have had Rockwood Ball Valves on this line for 3 years without maintenance.

Rockwood Valves prevent dripping and clogging of the pipe line, keeping production at a steady uninterrupted pace. There has to be a good reason for this kind of outstanding performance — and there is!

In fact, there are four excellent and exclusive reasons why Rockwood Ball Valves can give you such dependable service —

Full Round Flow — no change in shape or volume of fluid stream — no turbulence — no minimum loss

Quick Opening and Closing — only a quarter turn needed

Longer Wear-Resistance — chrome-plated bronze ball withstands abrasion, pitting and scratching

Leakproof Seal — pressure of fluid automatically positions ball against seat to form tight seal.

If you are not now using Rockwood Ball Valves, send coupon today for complete information. Valves come in all pipe sizes. Tested and listed by Underwriters' Laboratories, Inc. Distributors in all principal industrial areas.

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Send me illustrated folder V-4 on Rockwood Full-Flow Ball Valves.

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Title .....

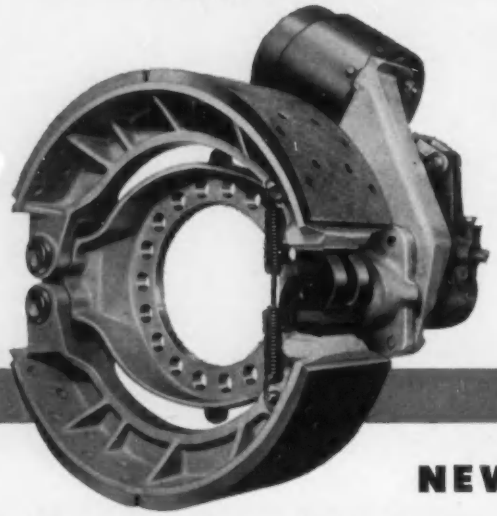
Company .....

City .....

Zone ..... *State* .....

TDA® BRAKES

if it rotates...we can control it!



Better control for the "heavyweights"

NEW TIMKEN-DETROIT® HEAVY-DUTY "P" SERIES POWER BRAKES

No earth mover is any better than its brakes. Dependable control is indispensable on *all* big construction vehicles. So it's important that manufacturers specify brakes that are large enough, safe and durable. No contractor can afford to have essential earth moving equipment side-lined because of brake problems.

Now! Timken-Detroit Brake Division offers the new He vy-Duty "P" Series Brakes to give manufacturers greater dependability . . . *better* control . . . and *longer* service.

The "P" Series Brak utilizes a unit-mounted design that offers a self-co. tained, compact assembly. Camshaft and air chamber support brackets are mounted directly onto the brake spider. (Inboard chamber mounting design is also available.)

Temperatures during operation are lower and liner life is longer because of the open-type spiders which assure good internal ventilation and rapid cooling. Timken® ¾" "Econo-liners" are tapered to provide greatest thickness where most wear occurs . . . less waste material at reline.

Other features of new "P" Series Brakes: heat-treated, malleable iron brake shoes . . . securely riveted brake linings . . . constant lift S-type, heat-treated cam . . . sealed, needle bearing camshaft mountings . . . long-life bronze bushings in anchor-pin holes . . . hardened, rust-proofed anchor pins.

"P" Series Brakes are available in a complete range of capacities and sizes to fit every operating requirement. For expert consultation, contact Timken-Detroit Brake Division. Complete specifications and information on "P" Series Brakes are available. And a staff of experienced engineers is ready to assist you with any problem you may encounter.

TIMKEN Detroit BRAKES
TIMKEN DETROIT BRAKE DIVISION
ROCKWELL SPRING AND AXLE COMPANY
ASHTABULA, OHIO
Accepted DA Standard
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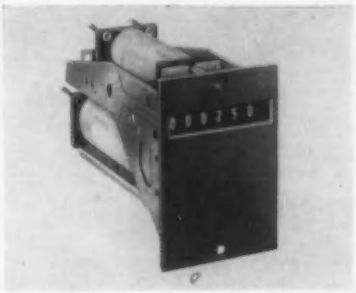
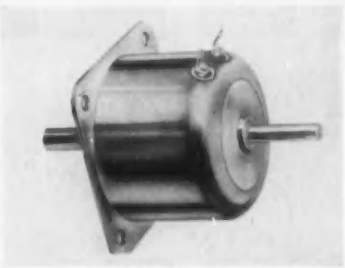
For every industrial, agricultural or automotive application where braking is required!

TDA plants at: Detroit, Michigan • Oshkosh, Wisconsin • Utica, New York
Ashtabula, Kenton and Newark, Ohio • New Castle, Pennsylvania



digit models have a counting speed of up to 10 impulses per sec. Landis & Gyr, Inc., 45 W. 45 St., New York 36, N. Y.

For more information—
Circle 82, inside back cover



Snap-Action Torque Solenoid

Because axial shaft movement is said to be eliminated, there is no need to absorb linear shaft motion. Units can be coupled direct to the load, without the intervention of splines or complicated linkages. Any degree of shaft travel is supplied, from 5 to 60 deg clockwise or counter-clockwise rotation, in increments as small as 1 deg, without extra tooling charge.

User can obtain any torque curve needed—whether flat, or with emphasis at the start or finish of the stroke. Torque values come as high as 15 in-lb or more, in a unit measuring $1\frac{1}{16}$ x $1\frac{3}{8}$ in. long. Pacific Solenoids, Inc., 208 Standard St., El Segundo, Calif.

For more information—
Circle 83, inside back cover

Through-Shaft Magnetic Disk Brake

The unit is designed so that the motor shaft extends right through the center and out beyond the end of the

(Continued on page 298)

poor paint adhesion?

FREE MANUAL
shows how phosphating will solve your problems!

If poor paint adhesion is your problem, chances are you'll find the solution in the Turcoat Phosphating Manual. This booklet describes the complete Turcoat line, tells the full story of phosphating and includes a valuable "Phosphating Reference Chart," which quickly gives the answer to any paint adhesion problem.

If you are interested in permanent paint adhesion, write today for the Turcoat Manual. There is no cost or obligation.

Offices in all principal cities

TURCO

TURCO PRODUCTS, INC.
Chemical Processing Compounds
6135 So. Central Ave., Los Angeles 1, Calif.
Factories: Newark, Chicago, Houston, Los Angeles

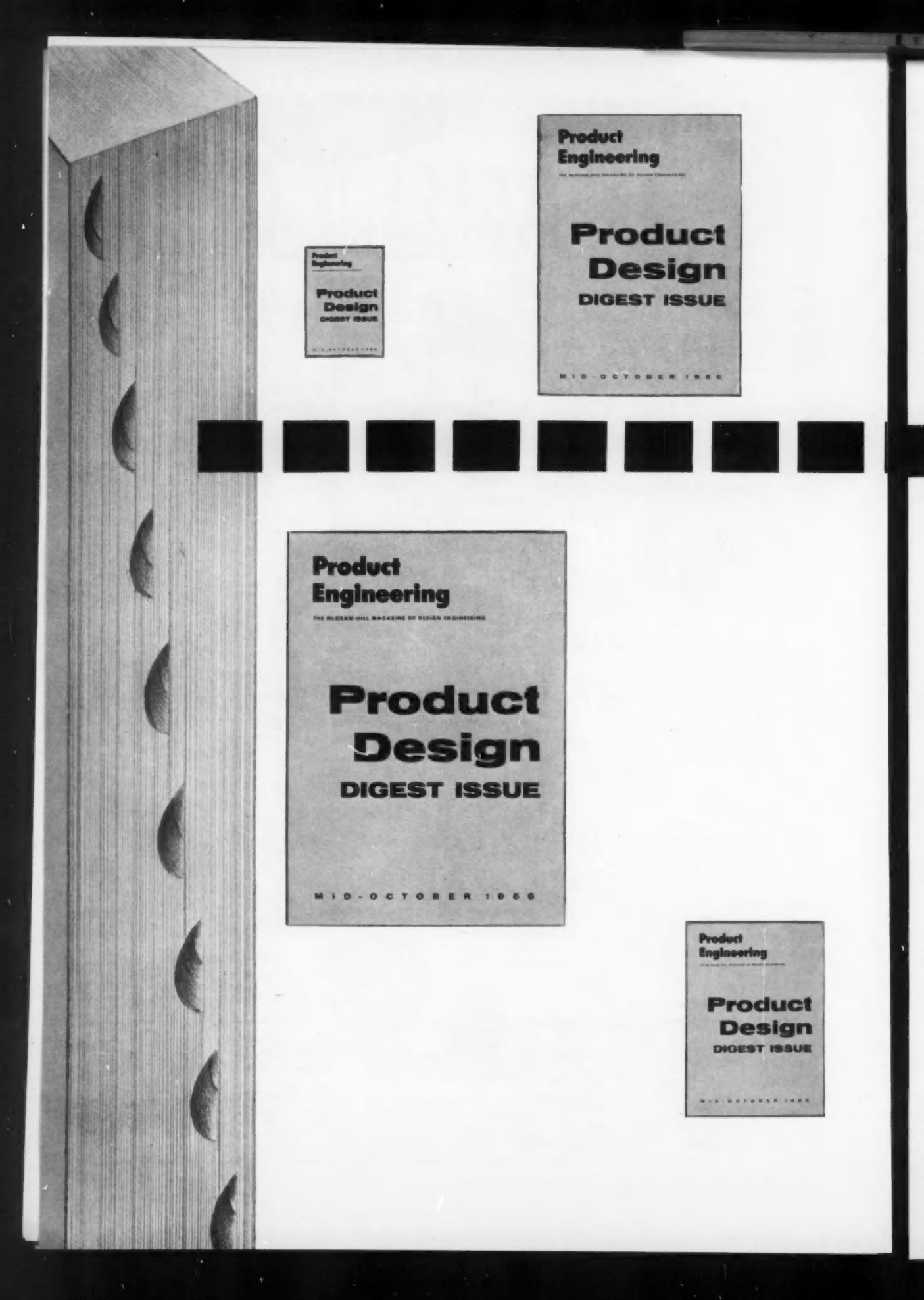
TURCOAT

You will be assured of a *permanent paint seal*, simply by using Turcoat as a bond for organic finishing.

Please affix coupon to company letterhead
TURCO PRODUCTS, INC.
6135 So. Central Ave., Los Angeles 1, Calif.
Please send me a copy of the Turcoat Manual without cost or obligation.

Name_____

Title_____ PE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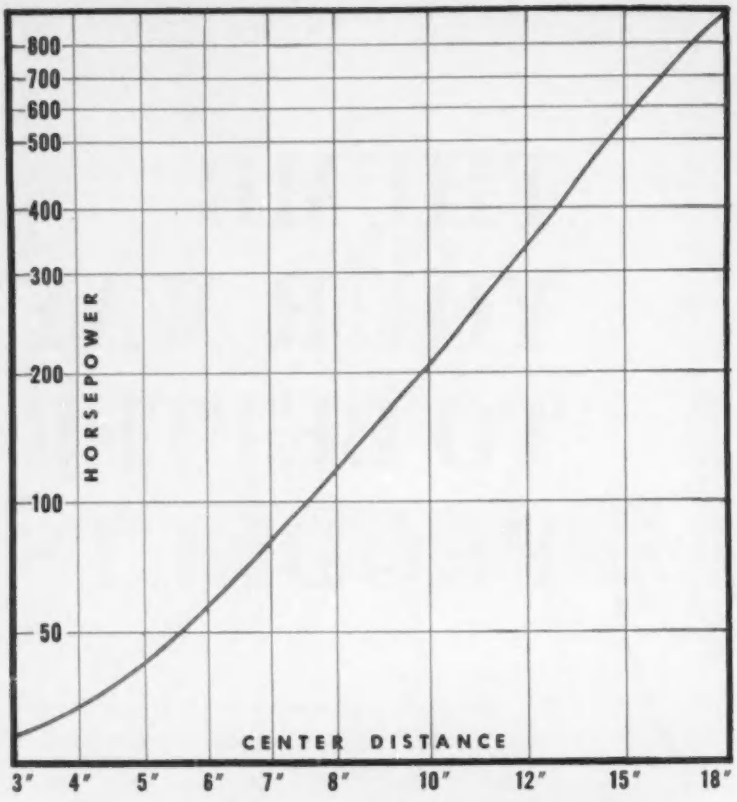
The product-design engineer most valued by his management . . . can find solutions to problems when they are most needed and wanted . . . can bring the benefits of new ideas and proven engineering principles to his company's products. Product Engineering's PRODUCT DESIGN DIGEST ISSUE helps you to be such an engineer. Thumb-indexed for quick reference, it puts at your fingertips hundreds of the most significant developments in the field of design engineering . . . facts and valuable data not readily available anywhere else. Over 21,000 technical articles will be screened by our separate, full-time, year-around editorial staff to make sure that the 1956 DIGEST ISSUE is the most helpful one yet. And, of course, you will get this valuable reference issue in mid-October as part of your subscription to *Product Engineering*.

Product Engineering

ABP ABC

THE McGRAW-HILL MAGAZINE OF DESIGN ENGINEERING

McGRAW-HILL BUILDING, NEW YORK 36, N.Y.



WE LEFT COMPETITIVE RATINGS OUT OF THE CHART PURPOSELY..

... because we think the load-carrying capacity of Cone-Drive speed reducers is pretty impressive all by itself. Then, we've also got a lot of friends in the worm gear speed reducer business. And they make pretty fair reducers themselves.

Two things are responsible for the high capacity of Cone-Drive speed reducers. First, we use extra-heavy gears mounted on oversize taper roller bearings in reinforced, heavy housings. Extra "beef' alone accounts for part of our capacity.

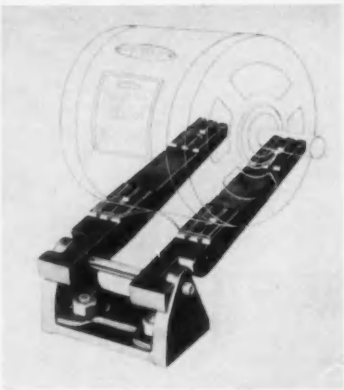
Even more important, however, is the Cone-Drive double-enveloping worm gear design. Here, we literally wrap worm and gear around each other to put ⅛ of all teeth in continuous full-depth contact. This results in spreading tooth contact ovet a greater area, reducing pressure on individual teeth, increasing load capacity and life of the gearing.

Ask for Bulletin 600C without obligation.

CONE-DRIVE GEARS
Division, Michigan Tool Company
DOUBLE ENVELOPING GEAR SETS & SPEED REDUCERS
7171 E. McNichols Road • Detroit 12, Michigan

brake, permitting drives off both ends of the shaft. The brake can be mounted on NEMA frames 65-C, 66-C, 182 and 184. Stearns Magnetic, Inc., Milwaukee, Wis.

For more information—
Circle 84, inside back cover



Motor Base for V-Belt Drives

This motor base automatically compensates for belt stress and maintains exact belt tension for all load conditions. The greater the load the greater the belt tension.

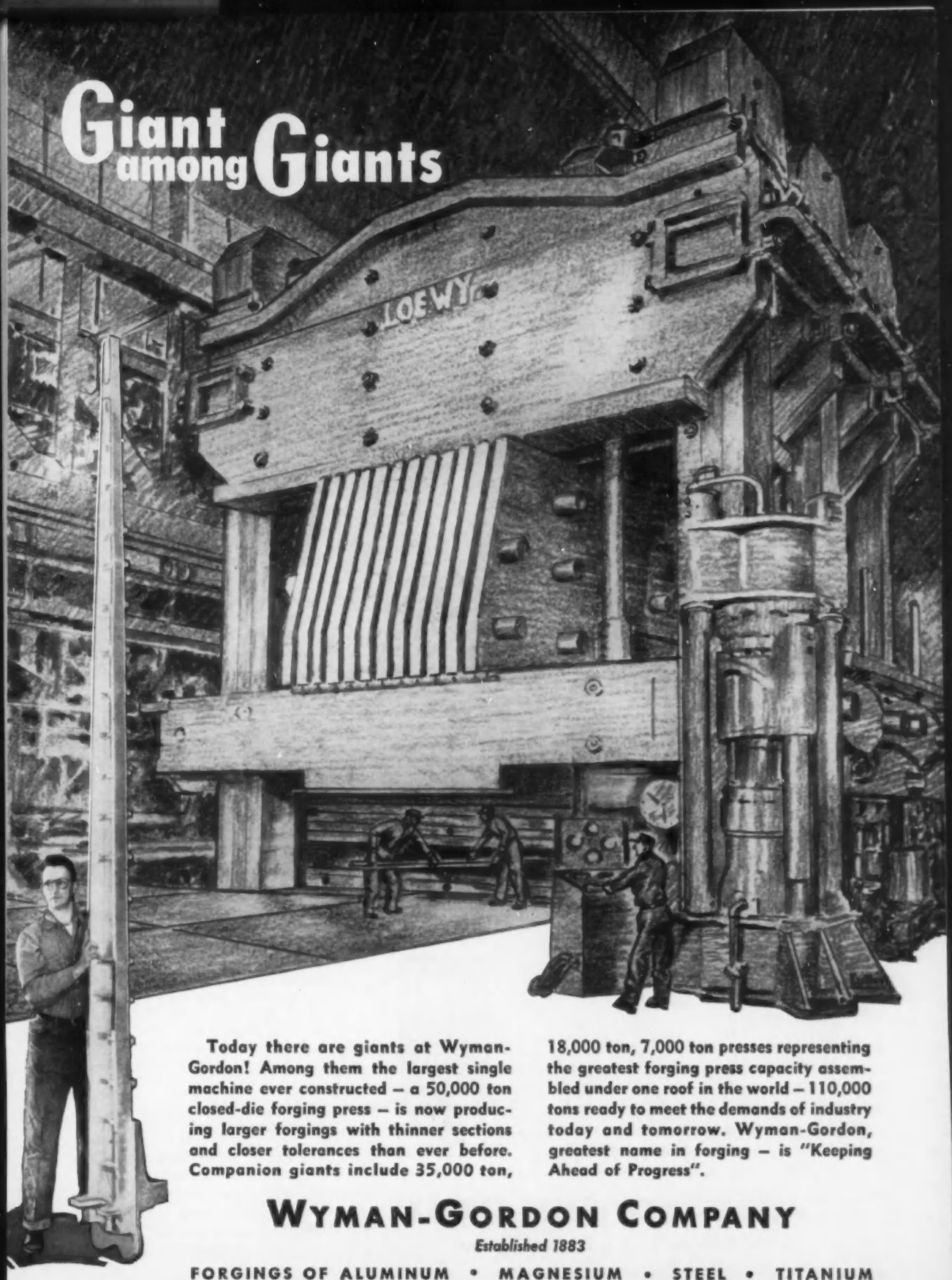
Belts can be changed without disturbing the mounting. It is available in four NEMA motor frame sizes from ½ to 7½ hp, and is designed for use with horizontally positioned drives. It is not for use on wall or ceiling mountings. Lovejoy Flexible Coupling Co., 4873 W. Lake St., Chicago 44.

For more information—
Circle 85, inside back cover

Four-Way Solenoid Valve

A valve produced for the control of air, water and light oil to 150 psi is designed to JIC specifications. The solenoid is inoperative when its cover

(Continued on page 300)



Today there are giants at Wyman-Gordon! Among them the largest single machine ever constructed – a 50,000 ton closed-die forging press – is now producing larger forgings with thinner sections and closer tolerances than ever before. Companion giants include 35,000 ton, 18,000 ton, 7,000 ton presses representing the greatest forging press capacity assembled under one roof in the world – 110,000 tons ready to meet the demands of industry today and tomorrow. Wyman-Gordon, greatest name in forging – is "Keeping Ahead of Progress".

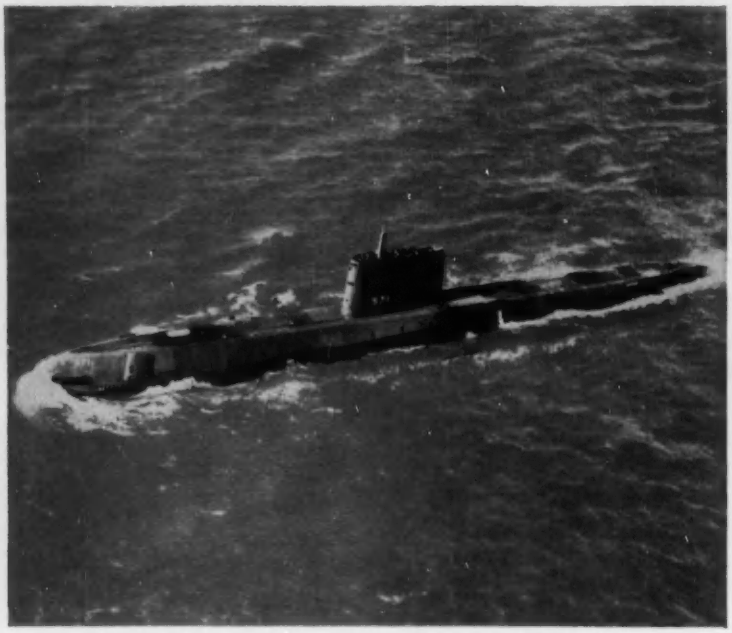
WYMAN-GORDON COMPANY

Established 1883

FORGINGS OF ALUMINUM • MAGNESIUM • STEEL • TITANIUM

WORCESTER 1, MASSACHUSETTS

HARVEY, ILLINOIS DETROIT, MICHIGAN

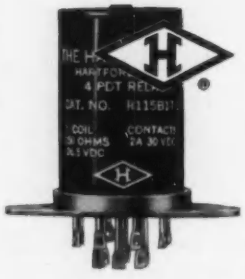


Official U. S. Navy Photograph

'Diamond H' Aircraft-type Relays Go to Sea in the Nautilus

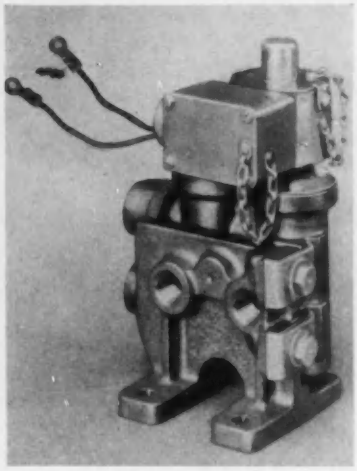
Their reliability proven in such critical land and air applications as guided missiles, jet engine controls and fire control systems, "Diamond H" miniature, hermetically-sealed, aircraft-type relays were chosen by Westinghouse for an important role in the world's first atomic-powered submarine. They're used in the reactor control system of the Nautilus.

Possible performance characteristics of "Diamond H" Series R 4 PDT relays span such broad ranges that the modifications which can be arranged to meet particular sets of requirements are almost endless. They're fully described in Bulletin R250, a copy of which is yours for the asking. Our engineers will gladly work with you to develop a variation for your specific need.



THE HART MANUFACTURING COMPANY

206 Bartholomew Avenue, Hartford 1, Conn.



is removed, and there is a manual override which is safe against accidental actuation. The conduit connector is threaded and the pressure ring terminals are on 6 in. free leads. The solenoid and the junction box are protected by captive cover plates which seal them against airborne contamination. The cover plates themselves are secured by captive screws. The valve can be quickly removed from the sub base simply by loosening three body clamps.

The valve can be converted to any practical current or voltage, ac or dc, by a coil change. Barksdale Valves, 5125 Alcoa Ave., Los Angeles 58, Calif.

For more information—
Circle 86, inside back cover

Lampholders for Two-Pin Miniature Lamps

These units are for use with GE No. 10, 12 or 15 lamps. They are supplied with wire leads or solder lugs, with or without jewel assembly, on a variety of mounting brackets. Drake Mfg. Co., 1711 W. Hubbard St., Chicago 22, Ill.

For more information—
Circle 87, inside back cover

Miniature Clutch-Brakes

A line of electro-magnetic combination clutches and brakes is available for electronic and instrument applications. Standard units deliver either brake or clutch torque when energized.

(Continued on page 303)

Idea Sparkers

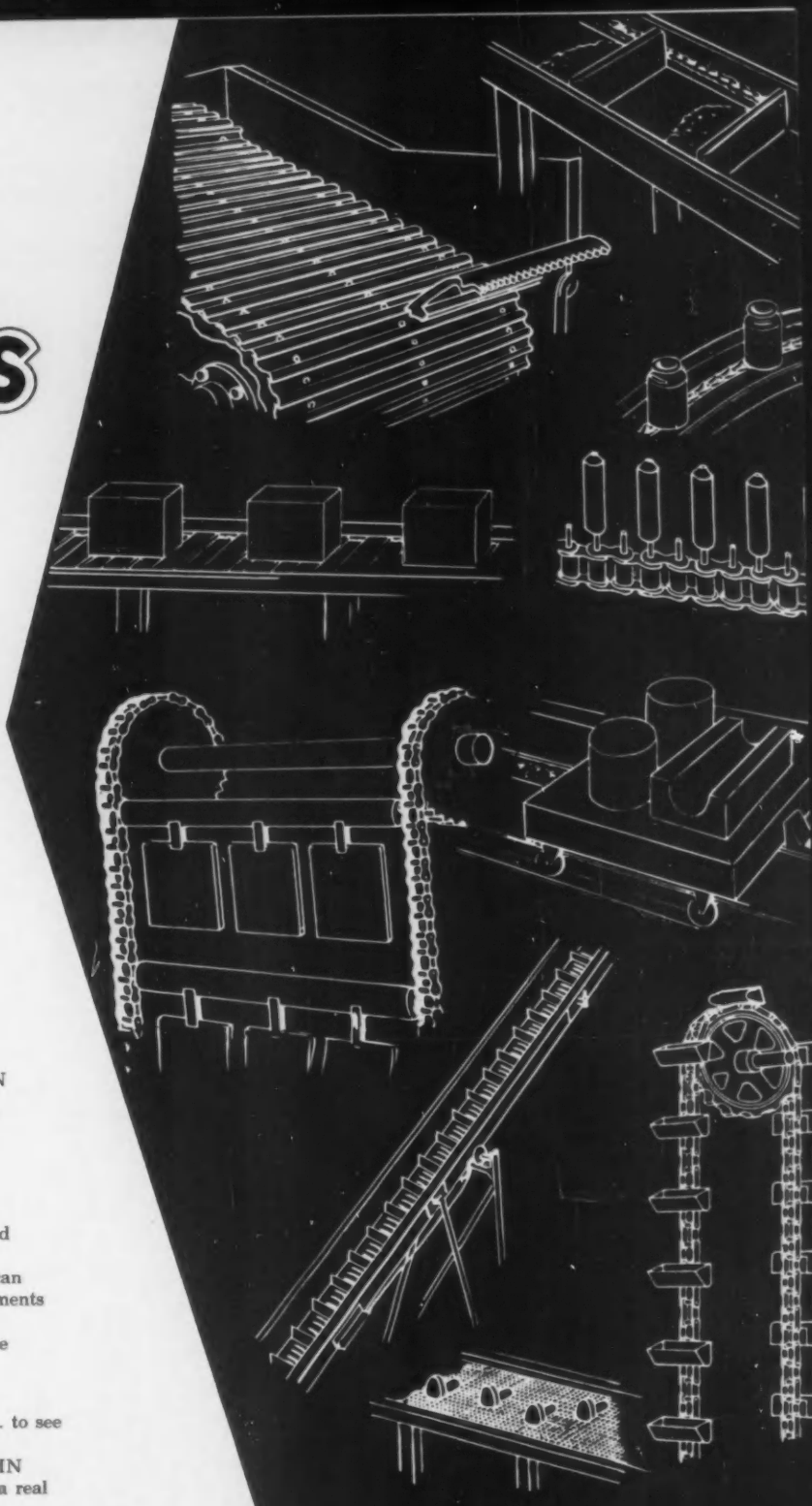
for

MATERIAL HANDLING

Ever been caught "dead center" on design . . . just needing a "spark" to trigger the idea you need to get going again?
Perhaps there's an idea here for you . . . a different use of chains and attachments that might help you find a better, more efficient way to move materials.

For example, in the complete CHAIN Belt line, there are dozens of different types of chain attachments that can be used in hundreds of different ways.
Bars, rods, slats, plates, tripping mechanisms, pins, tabs and many other devices can be simply fastened to chain attachments to perform a multitude of tasks. Many chains can operate as conveyors without attachments . . . using their surfaces as a carrier.
There are virtually no limits to the things you can do with efficient chain and attachments.

We'll be happy to work with you . . . to see if we can come up with an idea that can solve your problems. Your CHAIN Belt District Sales Engineer can be a real help to you, backed by our conveyor chain engineers.



TURN THIS PAGE FOR MORE INFORMATION

CHAIN BELT COMPANY

LEADERSHIP . . . through creative engineering

IDEA SPARKERS *(CONTINUED)*

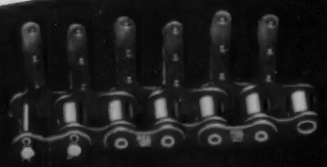
Why not send for informative literature on conveyor chains and attachments? You'll be amazed at ideas you'll get just from looking over the many attachments you probably never dreamed existed. Just mail the coupon below. There is no obligation.

REX

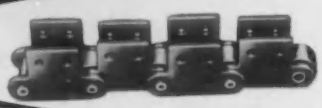
CONVEYOR CHAINS AND ATTACHMENTS

Rex Roller Chain with a K-1 attachment

Rex Roller Chain with a D-3 attachment

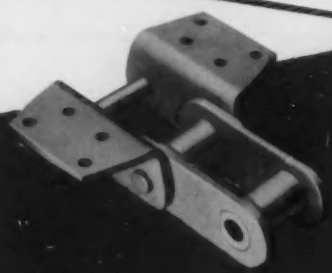


Rex Roller Chain with an M-3 attachment



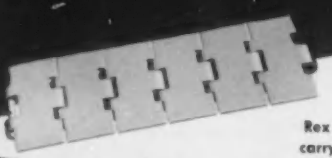
Rex Double Pitch Roller Chain with an M-2 attachment

Rex Double Pitch Roller Chain with a D-1 attachment



Rex Chabelco Steel Chain . . . best where loads are heavier or where operating conditions are severe.

Rex 9250 Chain . . . for carrying boxes, cartons, large cans. Will flex in two planes. Made in wear-defying Rex Z-Metal.



Rex TableTop Chain . . . a flat, level carrying surface, ideal for cans, bottles, jars, small parts and packages.

SELF-ALIGNING ROLLER BEARINGS

For effective protection of equipment . . . for longer service life at lower power costs, investigate Shafer Self-Aligning Roller Bearings.. Combining all the advantages of ball and roller bearings, these efficient units are your best choice for economical service.

CHAIN Belt Company
Dept. DP-3
Milwaukee 1, Wis.

☐ Send me informative literature on Rex Conveyor Chains and Attachments.
☐ Have my CHAIN Belt District Sales Engineer call.

NAME .....
COMPANY .....
ADDRESS .....
CITY..... ZONE..... STATE.....

CHAIN BELT COMPANY
MILWAUKEE 1, WISCONSIN

The device operates a brake when energized and is normaly clutched when de-energized.

High performance is coupled with small size and light weight. The servo-mounted units are available with output shaft at either or both ends. Units operate on d-c voltage.

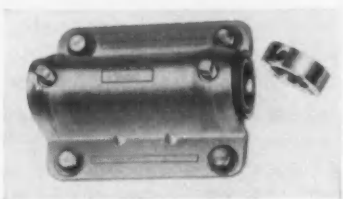
Typical models are 0.59 x 0.93 in. long (excluding input and output shafts), weighing 0.8 oz and delivering 4 in-oz combined brake and clutch torque. A. J. Thompson Co., Route 1 Box 812, Florissant, Mo.

For more information—
Circle 88, inside back cover

Molded Plastic Handle

This plastic handle is for machine tools, tractors, chain saws, dies and fixtures. It is stocked in $\frac{7}{16}$-20 and $\frac{1}{2}$-20 sizes. Chicago Screw Co., Div. Standard Screw Co., Bellwood, Ill.

For more information—
Circle 89, inside back cover



Self-Aligning Duplex Bearing Assembly

Adaptable to both vertical and horizontal mounting, this product combines two sleeve bearing ball assemblies in a single rigidized steel housing. This unit is available in two shaft sizes, $\frac{3}{4}$ and 1 in. complete. The range of shaft sizes extends from $\frac{1}{2}$ through

(Continued on page 306)

You can do things with these new ceramic magnets YOU COULDN'T DO BEFORE!

STACKPOLE CeraMAGNET®

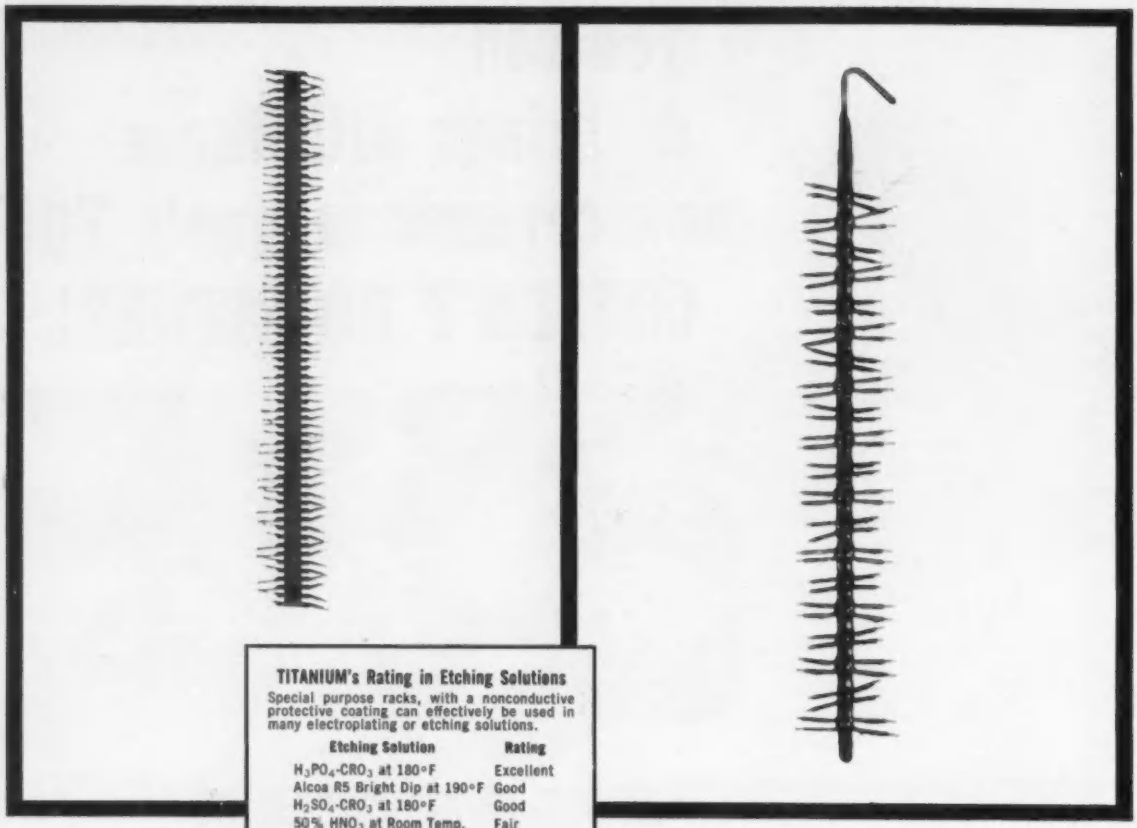
CERAMIC MAGNETS for HIGHER PERMANENCE plus ALMOST 100% ELECTRICAL RESISTANCE . . . AT LESS COST!

THE UNIQUE PROPERTIES of Stackpole Ceramagnet permanent magnets pave the way to new engineering concepts in magnetic usage. Moreover, the low cost of their non-critical ceramic material now makes magnets practical for applications where price of metallic units was formerly prohibitive.

For instance, Ceramagnet offers extremely high resistance to demagnetization—without "keepers" or closed circuit conditions, *and even in the presence of strong opposing fields.* Practically a non-conductor, Ceramagnet is ideal for high-frequency or high-voltage circuits. Coercive force is approximately 1650 oersteds. Remanent induction is 2010 gauss. Weight is only 4.85 gms/cm³. Temperature characteristics including retrace are linear to 400°C.

WRITE FOR BULLETIN RC-10A

Electronic Components Division
STACKPOLE CARBON COMPANY St. Marys, Pa.
Canadian Representative: Wm. T. Barron, P.O. Box 74, Toronto 14, Ont.



TITANIUM's Rating in Etching Solutions

Special purpose racks, with a nonconductive protective coating can effectively be used in many electroplating or etching solutions.

Etching Solution	Rating
H_3PO_4-CRO_3 at 180°F	Excellent
Alcoa R5 Bright Dip at 190°F	Good
H_2SO_4-CRO_3 at 180°F	Good
50% HNO_3 at Room Temp.	Fair

how TITANIUM cuts costs of anodized aluminum

Racks used for anodizing aluminum parts lead a rugged life. Sulphuric acid, and other highly corrosive solutions in which they're used, quickly eat up racks of ordinary materials . . . and production and labor costs go up.

But, made of TITANIUM, these same racks last *indefinitely*. For TITANIUM is not affected by any of the solutions used in anodizing — *is exceptionally resistant to most forms of corrosive attack*. And TITANIUM's high strength helps cut rack maintenance to practically zero.

For example, the anodizing racks shown here were designed and made by Omega, Inc., Litchfield, Connecticut. Joseph Reed, Jr., Omega's president, sums up TITANIUM's advantages this way: "True, the TITANIUM rack costs approximately three times as much as a conventional rack, but for any production run which will demand three or more sets of special purpose aluminum racks, TITANIUM is definitely the choice. After such runs, TITANIUM racks are still in good condition for future use."

This is no isolated example of how TITANIUM is cutting production costs. If you have an application calling for a metal that's *strong* (TITANIUM is as strong as steel, but weighs only half as much), *corrosion resistant*, and *easily formed* by normal shop methods, then TITANIUM may be for you, too. Your REM-CRU representative will be glad to help you make the best use of this versatile metal.

To keep abreast of the latest developments on this vital metal, write to Dept. P-5 for the Rem-Cru Review— a free periodical presenting the latest technical data on titanium alloys.

REM-CRU TITANIUM

REM-CRU TITANIUM, INC., MIDLAND, PENNSYLVANIA

Why limit yourself to "STOCK" sizes?

Hannifin can ship the cylinder you need within 48 hours!

(NEW AND EXPANDED PRODUCTION FACILITIES MAKE THIS POSSIBLE)

Any mounting style in:

Series "A" Square Head Air Cylinders—1½" to 14" bore
Series "H" Square Head Hydraulic Cylinders—1½" to 8" bore
Series "LW" Cast Head Air Cylinders—1" to 12" bore

Strokes
As specified to 60"

Rod Ends
Catalog standards, including standard alternates.
Most special rod ends require only 24 hours longer.

Cushions
Either or both ends if required

Quantity
Normally any quantity you need for rush jobs.
For large quantities specify your requirements.

order by phone
When the need is urgent
call long distance.
Experienced sales engineers
will handle your order

CALL HANNIFIN CYLINDER SALES
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Series "H"
Hydraulic Cylinders

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Series "A"
Air Power Cylinders

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HANNIFIN

Hannifin Corporation, 525 S. Wolf Road, Des Plaines, Ill.
Air and Hydraulic Cylinders • Hydraulic Power Units • Pneumatic and Hydraulic Presses • Air Control Valves

a better kind of power
for the food industry

The mark of an Extra Dependable machine

Investigate the *standard* and *special* motors engineered for food processing machinery by Electro Dynamic—America's leading producer of custom-built motors since 1880.

The red E.D. "power spot" is your assurance of *extra dependable* Electro Dynamic power—75 years in the making—yours today *at no extra cost!*

1 to 250 hp. AC and DC. Standard or special purpose. N.E.M.A. standards.

ELECTRO *xtra* **DYNAMIC** *ependable motors*

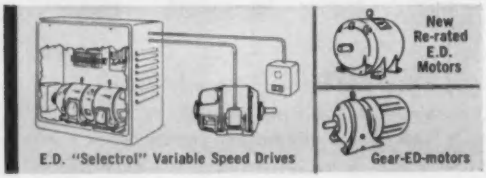
GD

PRODUCT OF GENERAL DYNAMICS

NEW...

Write for Brochure 100 and literature on new E.D. motors and drives.

Electro Dynamic division of General Dynamics Corporation Bayonne, New Jersey



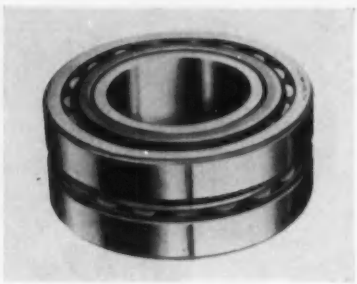
1 in. The housing measures 5⅛ x 4 x 2 in. high, with shaft center height at 1 in. Randall Graphite Bearings, Inc., Greenlawn Ave., Lima, Ohio.

For more information—
Circle 90, inside back cover

Snap-Back Recessed Handles

Designed for use on instruments, dust covers, spare parts boxes, electronic and portable equipment, carrying and reusable shipping containers, these handles open to 90 deg. The handles are available for load capacities from 200 to 350 lb, and the smaller aluminum model for a 75-lb capacity. Skydyne Inc., River Road, Port Jervis, N. Y.

For more information—
Circle 91, inside back cover



Self-Aligning Roller Bearings

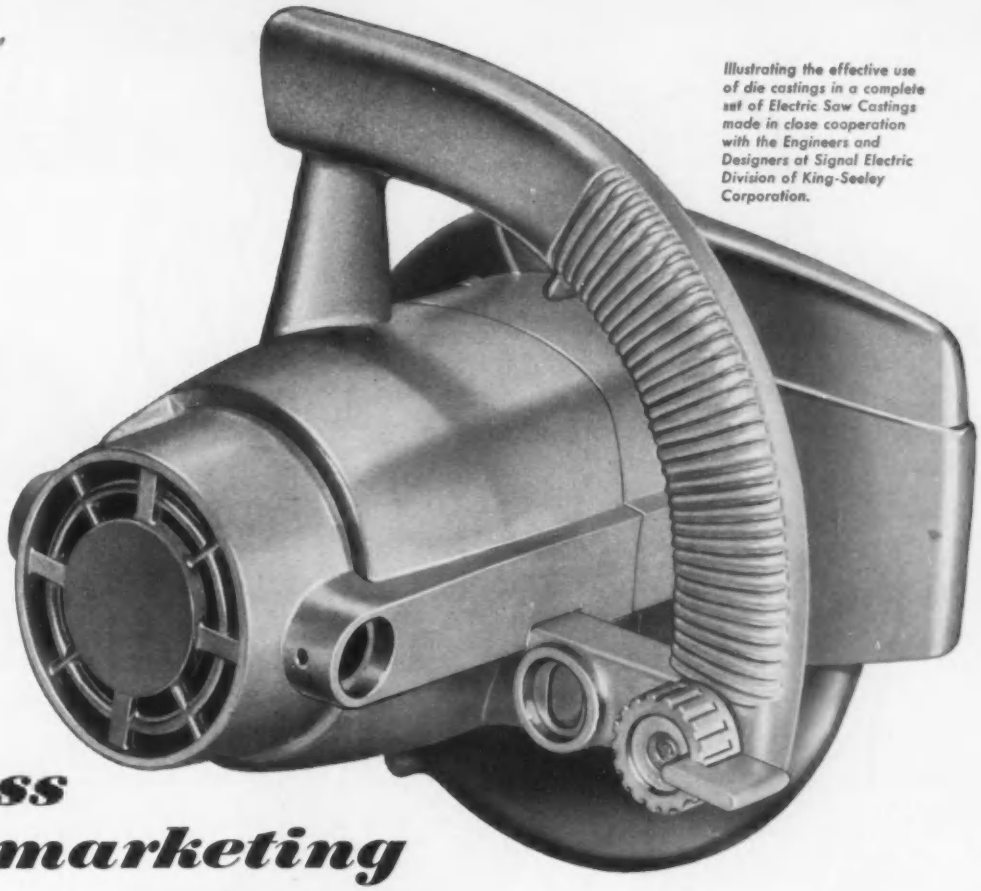
Book 2658, 8 pp, describes adjustable single-row self-aligning roller bearings, adjustable double-row bearings, and pre-adjusted double-row self-aligning bearings. It also gives engineering selection information, complete dimensional specifications and recommended fitting practices. Link-Belt Co., Dept. PR., Prudential Plaza, Chicago, Ill.

For more information—
Circle 92, inside back cover

Control Thyratron

The three new types of this 6.4-amp negative control thyratron all incorporate element and envelope construction designed to provide maximum cooling. The GL-6807 has a pin-type base and can be used interchangeably with the GL-5545. The GL-6808 has flexible "flying" leads and the

(Continued on page 310)



Illustrating the effective use of die castings in a complete set of Electric Saw Castings made in close cooperation with the Engineers and Designers at Signal Electric Division of King-Seeley Corporation.

mass marketing wisdom

with MADISON-KIPP zinc and aluminum die castings

A PRODUCT having instant and striking eye appeal sells more readily than one with a clumsy looking design. It sells better but probably not on "looks" alone. The buyer, consciously or unconsciously, may quickly conclude that good looks are combined with more thoughtful engineering—and he is right in such an evaluation.

To upgrade your product you may find that the skilled and seasoned mechanics at Madison-Kipp can be very helpful. Many highly placed engineers and designers have found this to be true for over a quarter of a century.

Please clip this ad as a reminder to contact us when you have die casting requirements.

kipp

MADISON-KIPP CORPORATION
206 WAUBESA STREET • MADISON 10, WIS., U. S. A.

Skilled in Die Casting Mechanics • Experienced in Lubrication Engineering • Originators of Really High Speed Air Tools

WOULD A TOUGHER STEEL CHANGE YOUR PLANS?

New Lukens "T-1" steel has three times the yield strength of carbon steel—cuts equipment weight, cuts costs!

■ Here's a new alloy steel with unusual resistance to abrasion, impact and atmospheric corrosion . . . that *stays* tough at temperature extremes. And where extra strength is required from plate steel, Lukens "T-1" steel makes possible substantial overall savings in material.

If you plan or purchase bridge parts, construction machinery or any general industrial equipment, check Lukens "T-1" steel now! Its rugged on-the-job performance can reduce maintenance expense and replacement costs—often provide longer service life!

The latest addition to a complete line of carbon, alloy and clad steels, this all-purpose material is obtainable from Lukens in the widest range of plate sizes available anywhere! Whether you want specific product information or the best ways to make the most of it, write to Manager, Marketing Service, 849 Lukens Building, Lukens Steel Company, Coatesville, Pennsylvania.

Whatever your plans—now's the time to change to . . .

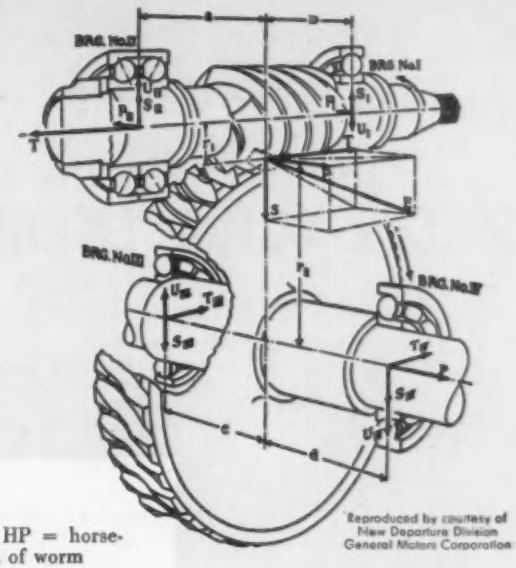
LUKENS "T-1" STEEL

LUKENS

THE NEWEST IN A COMPLETE LINE OF ALLOY STEELS
LUKENS STEEL COMPANY, COATESVILLE, PENNSYLVANIA

Helpful Data from
DE LAVAL

How to Calculate Worm Gear Bearing Loads



Reproduced by courtesy of New Departure Division General Motors Corporation

$Q = \frac{HP \times 63025}{N}$ = TORQUE INPUT to worm, lbs. inches; HP = horsepower transmitted and N = rev. per min. of worm

$P = \frac{Q}{r_1}$ = TANGENTIAL FORCE of worm, where

r_1 = Pitch radius of worm in inches
[r_2 = Pitch radius of worm gear
$= \frac{1}{2\pi}$ (number of teeth in gear x axial worm pitch)]

$S = \frac{P \tan \alpha}{\tan \gamma}$ = SEPARATING FORCE, where

α = Axial tooth pressure angle*

γ = Helix or lead angle of worm*

$= \tan^{-1} \frac{\text{lead}}{2\pi r_1}$, or $\tan^{-1} \frac{\text{Number of threads x axial worm pitch}}{2\pi r_1}$

$T = \frac{P}{\tan \gamma}$ = WORM THRUST, or tangent force driving worm gear

* LEAD ANGLE 0°-35° use 27½° Pressure Angle
LEAD ANGLE 35°-45° use 30° Pressure Angle

BEARING LOADS

Due to	on Brg. I	on Brg. II
P	$P \frac{a}{a+b} = P_I$	$P \frac{b}{a+b} = P_{II}$
S	$S \frac{a}{a+b} = S_I$	$S \frac{b}{a+b} = S_{II}$
T	$T \frac{r_1}{a+b} = U_I$	$T \frac{r_1}{a+b} = U_{II} = U_I$
Total Rad. Load	$\sqrt{P_I^2 + (S_I - U_I)^2}$	$\sqrt{P_{II}^2 + (S_{II} + U_{II})^2} = R_{II}$
Thrust Load		T
Total Load	$\sqrt{P_I^2 + (S_I - U_I)^2}$	$\sqrt{R_{II}^2 + T^2}$
Due to	on Brg. III	on Brg. IV
P	$P \frac{r_2}{c+d} = U_{III}$	$P \frac{r_2}{c+d} = U_{IV} = U_{III}$
S	$S \frac{d}{c+d} = S_{III}$	$S \frac{c}{c+d} = S_{IV}$
T	$T \frac{d}{c+d} = T_{III}$	$T \frac{c}{c+d} = T_{IV}$
Total Rad. Load	$\sqrt{T_{III}^2 + (U_{III} - S_{III})^2}$	$\sqrt{T_{IV}^2 + (S_{IV} + U_{IV})^2} = R_{IV}$
Thrust Load		P
Total Load	$\sqrt{T_{III}^2 + (U_{III} - S_{III})^2}$	$\sqrt{R_{IV}^2 + P^2}$

Speed Change

$$\text{Gear rpm} = N \times \frac{\text{Number of threads in worm}}{\text{Number of teeth in gear}}$$

For simplicity in bearing load computations for worm gearing, the normal tooth force E is treated in terms of its three perpendicular elements, namely, P, the tangential driving force at pitch radius of worm; S, the force tending to separate worm from the gear, due to the pressure angle; and T, the thrust produced by the lead or helix angle of the worm.

Catalog 5000 contains helpful worm gearing application and specification data. Write on your business letterhead to the De Laval Steam Turbine Company, 801 Nottingham Way, Trenton 2, N. J.

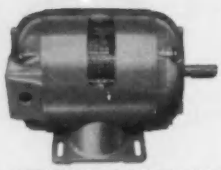
SAVE

on original development costs
by using REULAND ELECTRIC'S

SPECIAL-MOTOR "LIBRARY"

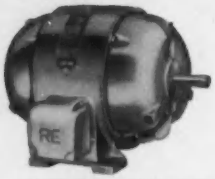
Over 900 Different
Electric Motors

MOTOR #810



CAN BE STALLED OR "LOCKED" WITH CURRENT ON without damage. This torque motor automatically adjusts to intermittent load changes, yet maintains constant power. Available in locked service duties of 5%, 10%, 25%, 50% and 100% with maximum stalls of 5, 10, 20 or 60 minutes, *or continuous* stall.

MOTOR #569

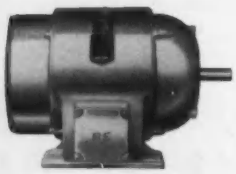


MULTI-SPEED MOTOR operates at different speeds as desired. Available in 2, 3 or 4-speed ratings in the following types:
Constant Torque—Constant torque regardless of motor's speed.
Variable Torque — For loads that maintain their own momentum.
Constant H.P.—Constant H.P. even at reduced motor speed.

MOTOR #617

WAFER-THIN, AIR COOLED, TOTALLY ENCLOSED. Originally designed for ventilation and air moving installations where it could be direct-connected to the fan *within* the piping or vent. Direct-fan attachment eliminates pulleys, belts, brackets and fan shaft. Can also be supplied in open type for mounting out of airstream.

MOTOR #402



HIGH STARTING TORQUE ON LOW STARTING CURRENT, plus variable speed are offered by the Slip Ring motor. Often permits using regular current for getting heavy loads up to full speed. Cranes, heavy fans, printing presses and crushers are typical uses. Available separately or with single or double reduction gear reducers.

REULAND'S "XPANDABLE" DESIGN MEANS ALMOST UNLIMITED ADAPTABILITY . . .

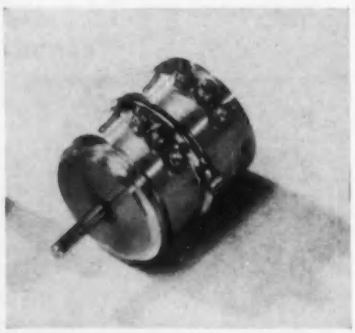
Don't pay for special motor development until you first check the Reuland SPECIAL-MOTOR LIBRARY. Reuland's revolutionary new XPANDABLE DESIGN idea has produced literally hundreds of unique power packages, one of which may already be the answer to your needs.

Reuland also produces a complete line of standard electric motors. Free engineering literature will be sent upon request. Your inquiry will be given prompt, personal attention.

RE **REULAND ELECTRIC COMPANY**
Distributors In All Principal Cities
Western Division: Alhambra 28, Calif. — Eastern Division: Howell 28, Mich.

GL-6809 is made with spade lug terminals extending from the base. Maximum average cathode current of these motor control thyratrons is 6.4 amp and fault current 1120 amp. Maximum negative control grid voltage before conduction is 250 v, and during conduction it is −10 v. Maximum positive control grid current is 0.20 amp with the anode positive and 0.10 amp with the anode negative. General Electric Co., Schenectady 5.

For more information—
Circle 93, inside back cover



Single-Turn Potentiometers

This line includes all sizes from ¼ to 3 in. dia. Bases are of aluminum alloy, gold-anodized. Stainless steel clamp rings permit easy phasing and secure clamping of ganged units. Radial shaft play is reduced to 0.0003 in. max, and concentricity is 0.0003 in. All connections soldered or welded except sliding contacts which are of precious metal. Bronze bearings are lubricated for life.

Temperature range is −50 C to

(Continued on page 314)

COPPER gives you more to talk about

Are you in a business whose product needs constant selling? Most products do.

Perhaps yours must be sold to many people . . . your own sales organization . . . distributors, retailers, consumers.

Copper gives you more to say for your product.

And especially where you're selling against competition, *copper can make the difference.*

For no substitute possesses the combination of characteristics you get . . . and offer . . . in copper and its many versatile alloys.

Today, as always, the phrase "made with copper" signifies *quality.*

That's because people's experience with copper is favorable. There is no doubt about copper's performance.

If mere acceptance isn't enough for your product . . . if competition makes *preference* important . . . give yourself the advantage of copper or one of its many alloys.

You will find that COPPER gives you more to talk about—*helps you sell!*

COPPER & BRASS
RESEARCH ASSOCIATION

420 Lexington Avenue, New York 17, N. Y.

. . . AN INDUSTRY SOURCE OF TECHNOLOGICAL AID, INCLUDING A LIBRARY OF TECHNICAL LITERATURE AND A COUNCIL OF SPECIALISTS

COPPER OR ITS ALLOYS PROVIDE THESE ADVANTAGES:

Best conductor of electricity commercially available

Does not rust . . . high corrosion resistance

Best heat transfer agent of all commercial metals

Easy to machine, form, draw, stamp, polish, plate, etc.

Welds readily . . . excellent for soldering and brazing

GRC DIE CASTS MOVABLE PARTS IN ONE UNIT; NO ASSEMBLY, BETTER DESIGN, LOWER COST

GRC "Intercast" swivel ring on left cast—assembled complete in single operation. Ring on right required assembly of two screw machine parts plus a metal stamping.

"Intercast", exclusive Gries' cast-assembly technique of die casting small zinc-alloy movable-parts affords production economies, better appearance in manufacture of picture frame rings.

Previously, Metalcraft Corp., leading manufacturer of picture frames needed two screw machine parts, a metal stamping plus two asembly operations to complete their picture frame swivel rings. With Gries "Intercast" production, a single automatic operation casts the unit completely assembled, trimmed, and ready for use. The manufacturer eliminated assembly entirely, effected economies of over 50% and received a more attractive component.

"Intercast" is only one of the exclusive Gries die-casting techniques and processes that offer industry drastic reductions in production costs and new opportunities for improved design. Unique GRC machines turn out simple or intricate small parts, complete, in one high-speed automatic operation. Many manufacturers have found that Gries facilities give them a better product while reducing costs and eliminating machining and assembly operations.

Gries small zinc alloy die cast parts are made to fit size, shape and tolerance specifications *precisely*. Smallness is unlimited (maximum weight ½ ounce, maximum length 1¾ inches). All are mass-produced at low cost in quantities of 100,000 to many millions.

Send for further information on "Intercast" and other Gries small-parts production facilities, and find out how they can be applied to your particular problems.

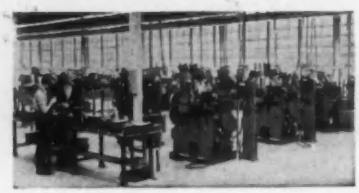
Wide Variety of Stock Parts Available from Gries

Zinc-alloy and plastic molded products and components covering hundreds of industries can be obtained from GRC. Industrial fasteners such as wing nuts and cap nuts, are produced in great volume, along with saddlery, awning, drapery and window hardware items, nylon coil bobbins, washers and valve seats; die-cast gears and pinions in hundreds of standard combinations. Many other specific parts available; write for specific information today.

GRC Gives Help on Design and Production Problems

To learn how designs can be simplified and assembly operations reduced or eliminated, write for useful reference copy of Gries' fact-filled bulletin. In addition, Gries's staff is available to manufactuers for personal consultation on design and production of GRC automatically die-cast and plastic - molded small parts.

GRC Offers Extensive Facilities



In the modern Gries plant, complete production facilities for small precision parts plus a highly qualified engineering staff guarantee the manufacture of even the tiniest, most intricate components to exact specifications. In addition to complete production tooling and design development, comprehensive facilities are available for secondary operations . . . machining, tapping, threading, assembly, etc. Practically all commercial finishes can be applied in the complete Gries plating department.

GRC will be at the Design Engineering Show; BOOTH 235-237

WORLD'S FOREMOST PRODUCER OF SMALL DIE CASTINGS

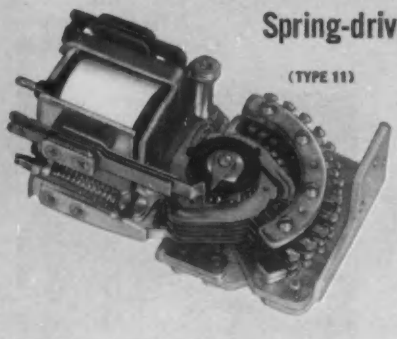
GRIES

GRIES REPRODUCER CORP.

159 Beechwood Ave., New Rochelle, N. Y. NEw Rochelle 3-8600

CLARE

Spring-driven Stepping Switch

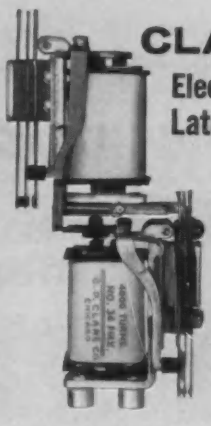


(TYPE 11)

Latest in CLARE line of uniselectors, or rotary switches for completing, interrupting or changing connections in a succession of electric circuits in response to momentary impulses of current. Provides millions of steps without readjustment. *Send for CLARE Bulletin No. 121.*

CLARE

Electromechanical Latching Relays



Assembly consists of two CLARE a-c or d-c relays with interlocking armatures. One a-c and one d-c relay may also be used. Many of these relays still operating satisfactorily after well over 15,000,000 operations. *Send for CLARE Bulletin No. 118.*

New CLARE RELAY designs keep pace with demands of modern high-speed equipment

CLARE RELAYS for use in modern high-speed devices differ in size, shape, appearance and characteristics to meet a wide range of design requirements.

One factor they have in common—ability to deliver accurate and dependable performance for millions, yes even billions, of operations WITH NO MAINTENANCE WHATSOEVER.

A few of these outstanding CLARE developments are shown. There are many more. If your relay problem is new or unusual, CLARE sales engineers, located in key cities, may be able to bring you quickly just the relay you need. Contact C. P. CLARE & CO., 3101 Pratt Blvd., Chicago 45, Illinois. In Canada: C. P. CLARE & CO., 659 Bayview Avenue, Toronto 17. Telephone: Mohawk 3829.
Cable address: CLARELAY.

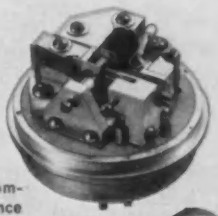
CLARE

Mercury-Wetted Contact Relays

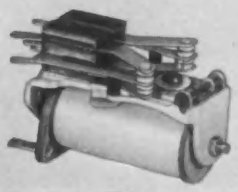
A relay of the utmost accuracy and dependability which is capable of over a billion operations at speeds to 60 operations per second. Cutaway view shows mercury-wetted contact switch sealed in glass. Available with up to 4 switches for multiple circuits. *Send for CLARE Bulletins Nos. 120 and 122.*

CLARE

High Frequency Impulse Relay



A highly sensitive relay completely free from contact bounce and capable of billions of operations at extremely high speed. (Will follow up to 2,500 CPS.) *Send for CLARE Bulletin No. 117.*



CLARE

Type J Heavy-duty Contact Relay

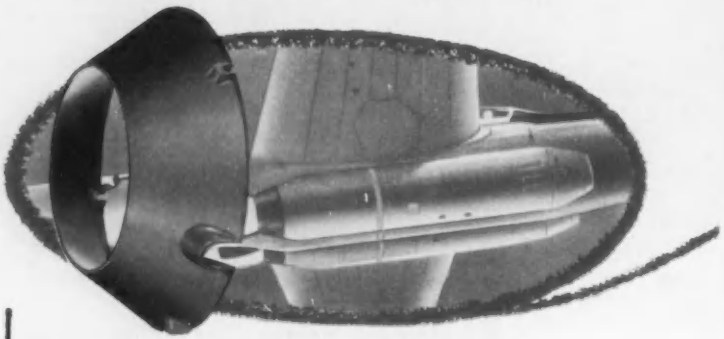
Increased current carrying capacity is provided by the use of silver heavy-duty contacts which are riveted to the springs. Rating of 10 amperes, 27½ volts d-c. Has exceeded 500,000 operations on motor load of six amperes—inrush current of 15 amperes—at 70,000 feet altitude. *Send for CLARE Bulletin No. 119.*

CLARE RELAYS

FIRST in the industrial field

THE SHAPE OF THINGS IN MOLDED SILICONE

SILI-CONE PROVES REAL COOL FOR JET AIRCRAFT EQUIPMENT



APPLICATION:
Thermal barrier for jet aircraft accessories.

PROBLEM:
The original part, along with drawings and molds, was presented to Acushnet by a well-known manufacturer of accessories for conventional and jet aircraft with orders to continue development with Dow-Corning 301 compound. The idea was to attain a part that would provide maximum physical properties at elevated temperatures of over 800°F.

SOLUTION:
Overcoming the high bulk factor of the compound was accomplished through the design and construction of a preform. Running the original mold in a special hydraulic ram equipped with controls permitting a wide range of temperatures and pressures, provided the necessary information in curing this compound. The resultant cure times and pressures enabled Acushnet engineers to design and construct a compression mold of hardened steel that made this part possible. Included in this project were small gaskets molded from Dow-Corning 301 that proved superior to metal in high heat insulating applications.

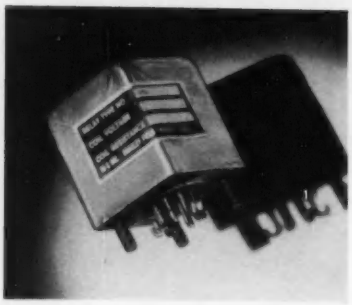
Pioneers in the advanced mold techniques and custom compounding of silicones. Acushnet now offers you immediate technical assistance in the molding and finishing of silicone resins.
Send for Acushnet "Rubber Data Handbook."
What's Your Shape?

Acushnet

ACUSHNET PROCESS COMPANY
NEW BEDFORD, MASSACHUSETTS
... *Precision Molded* RUBBER, SILICONES - "APCOTITE" BONDING
Address all communications to 768 Belleville Ave., New Bedford, Mass.

125 C. Units have been designed and built to operate for 50 million cycles at 3000 rpm. Precision Line, Inc., 63 Main St., Maynard, Mass.

For more information—
Circle 94, inside back cover



Subminiature Relay

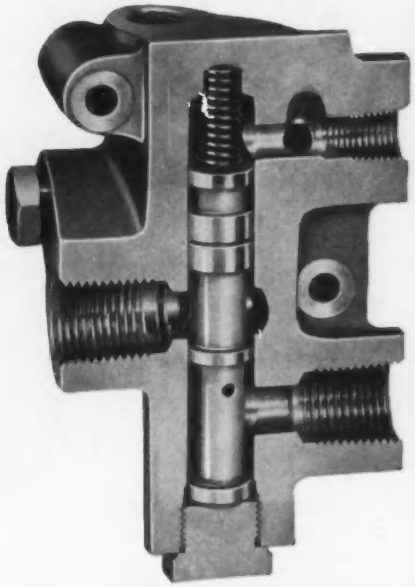
Hermetically sealed relay measures 1 in. sq, 1⅝ in. high. Operating temperatures to 125 C with long-life characteristics at rated contact loads of 2 amp at 28 v, dc, or 115 v, ac. Coil resistance ranges of 50 to 10,000 ohm. Hook terminals or straight pins for plug-in and printed circuit applications are standard. Available in Form A, B or C contact arrangement with a maximum of two poles. HI-G, Inc., Bradley Field, Windsor Locks, Conn.

For more information—
Circle 95, inside back cover

Tandem Transistor

The d-c coupled transistor elements are housed in a single case and form a simple two-stage cascade. The tandem transistor combines extremely high current and power gain with a high ratio of input-to-output resistances. In addition it is a variable-B (Beta) transistor equivalent to a variable μ

(Continued on page 316)



NEW Webster Flow Divider

THE MOST ECONOMICAL ANSWER FOR POWER STEERING

and other dual applications

WEBSTER'S NEW FLOW DIVIDER is a specially developed flow control valve specifically designed to provide the utmost economy in power steering and other applications where two separate hydraulic power circuits are to be served. It has been used with great success on agricultural equipment, road-building machinery, materials-handling equipment, and for many other purposes. Its advantages include:

Greatest Economy • Use of the Flow Divider eliminates any necessity for a second hydraulic pump and driving medium—cuts equipment and installation costs substantially.

Less Hydraulic Piping • Use of the Flow Divider simplifies and reduces the amount of hydraulic piping required, since it eliminates the inlet piping which would be required for a separate pump, and it can be installed close to the secondary demand.

Flexibility • The Flow Divider can be installed remotely from the pump, thus providing greater flexibility in the design of hydraulic circuits.

Compactness • The small size (2"x 3"x 5½") of the Flow Divider eliminates installation problems.

In most applications the Flow Divider is adjusted to provide constant flow to the secondary system. For example, in power steering applications 2½ gpm are constantly diverted to the steering circuit. However, Flow Dividers can also be adjusted to allot pump capacity proportionately between primary and secondary circuits.

The Flow Divider has a capacity of up to 20 gpm at 2000 psi. A built-in damping device prevents noise, eliminates "hunting" effect. It can be provided with a built-in relief valve, if desired.

TANDEM PUMP COMBINATIONS

For those dual applications where you want two pumping units, Webster's Tandem Pump Combinations provide an economical, completely dependable answer. Rated at 1000 psi and 1750 rpm, these combinations are provided with a capacity range for the larger pump from 4.8 to 29.0 gpm. The small pump has a capacity range from 1.0 to 4.0 gpm.

Write today for complete information

AH-3

- ☐ Please send us complete information on Webster Flow Divider
- ☐ Please send us complete information on Tandem Pump Combinations
- ☐ Please send catalog on complete Webster line

Name_____

Title_____

Company_____

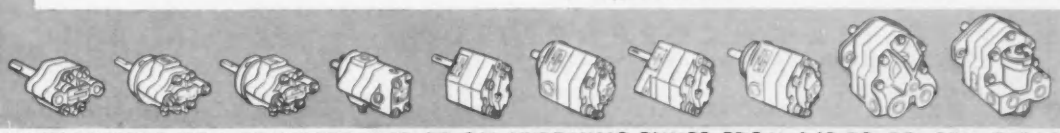
Street_____

City, Zone & State_____

OIL HYDRAULICS DIVISION

WEBSTER ELECTRIC

RACINE • WISCONSIN



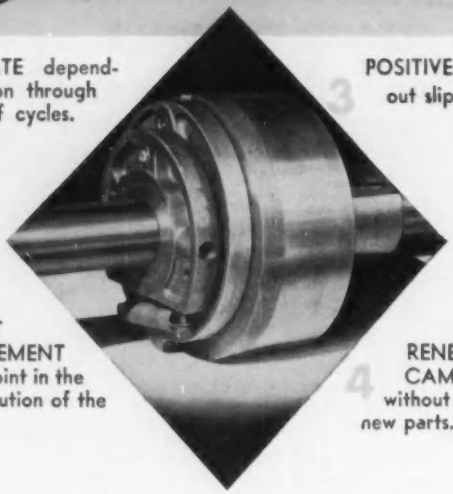
MANUFACTURERS OF A COMPLETE LINE OF OIL HYDRAULIC PUMPS FROM 1/5 TO 30 GPM CAPACITY

HILLIARD CLUTCHES FOR POWER CONTROL DESIGNS

HILLIARD
Single Revolution CLUTCH

1 ACCURATE dependable action through millions of cycles.

3 POSITIVE motion without slip or lag.



2 INSTANT ENGAGEMENT at any point in the the revolution of the driver.

4 RENEWABLE CAM SURFACES without machining or new parts.

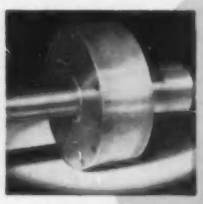
The Hilliard Single Revolution Clutch *is automation* because it provides precise accurate intermittent motion automatically. Control can be electrical or mechanical.

The use of Hilliard Single Revolution Clutches has improved the operation of tube straightening and cut-off machines—shears—conveyors—riveting and fastening units—case loaders—bottle unscramblers—weighing and packaging—indexing and feeding—marking—punching—textile and business machines—radar apparatus—proportionate pumps—and many other types of mechanisms.

WRITE TODAY FOR BULLETIN 239 WITH COMPLETE INFORMATION.

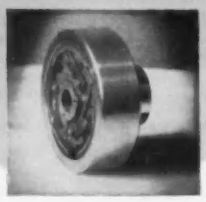
• OTHER HILLIARD CLUTCHES •

CONSIDER AUTOMATION - INVESTIGATE THESE PRODUCTS



HILLIARD - TWIFLEX CENTRIFUGAL COUPLING for smooth, easy starting of any load automatically with overload protection and ability to accommodate shaft misalignment. Ask for Bulletin CE-3.

OVER-RUNNING CLUTCHES for automatic instantaneous engagement and release on two speed drives, dual drives and ratchet or backstop action. Ask for Bulletin 231.



SLIP CLUTCHES for overload protection, or constant torque and to provide constant tension and permit speed variation on rewind stands. Ask for Bulletin 300.

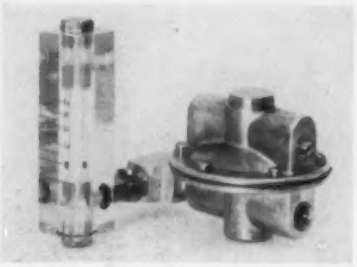
THE HILLIARD CORPORATION
MANUFACTURING CLUTCHES FOR OVER 50 YEARS

101 W. FOURTH ST. ELMIRA, N. Y.

IN CANADA: UPTON • BRADEEN • JAMES, LTD.

pentode. Marvelco Electronic Div., National Aircraft Corp., 3411 Tulare Ave., Burbank, Calif.

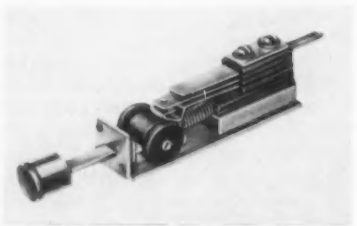
For more information—
Circle 96, inside back cover



Differential Regulator

A differential pressure regulator incorporating a self-contained needle valve can be used for purging with air, water, or gas, in services where actual measurement of the flow is unnecessary. Ranges from 0.2 to 2.0 cfh of air and 20 to 200 cc per min of water are available. Conoflow Corp., 2100 Arch St., Philadelphia 3, Pa.

For more information—
Circle 97, inside back cover



Pushbutton Switch

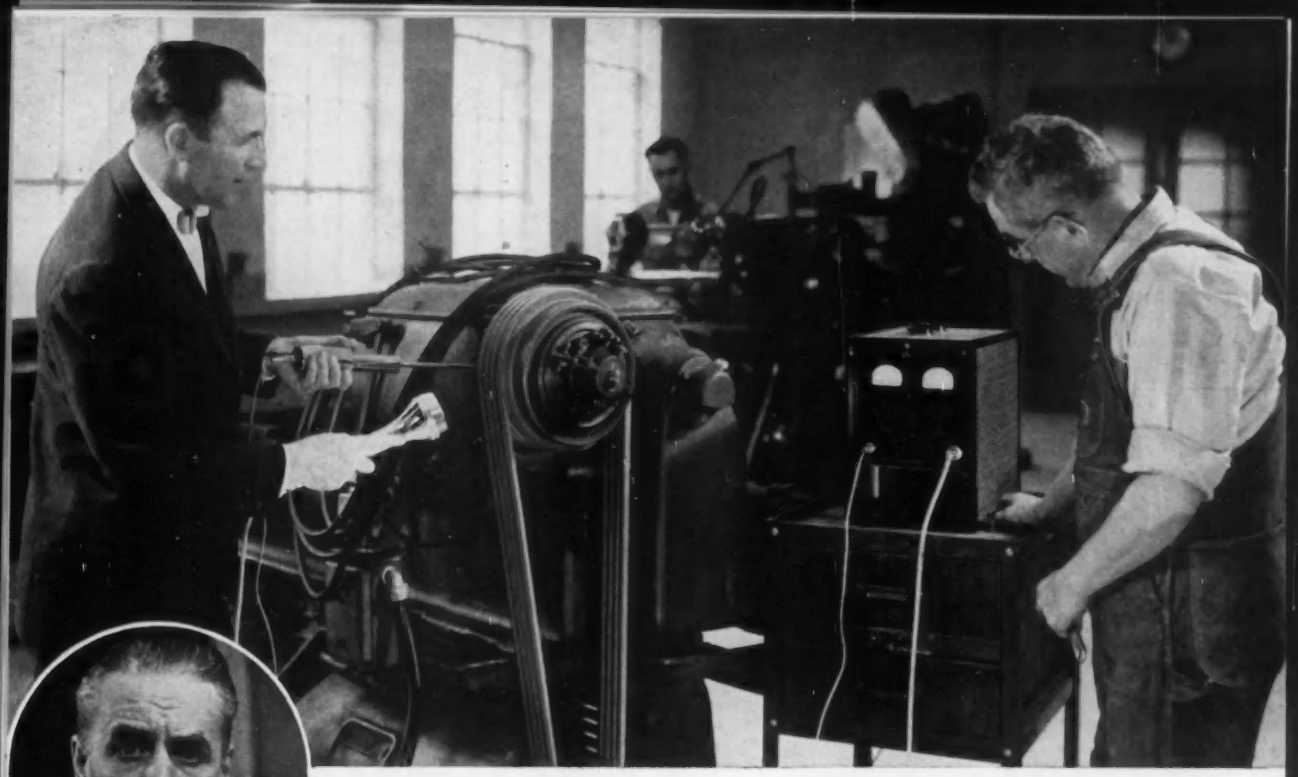
A momentary action, pushbutton switch has a plunger mounted on phenolic rollers. Requiring 2⅜ in. depth behind panel, the switch has palladium contacts. Rating is for 3 or 5 amp, 110 v, ac (non-inductive). Donald P. Mossman, Inc., Brewster, N. Y.

For more information—
Circle 98, inside back cover

Regulated D-c Power Supplies

Four rack-mounted power supplies have a panel height of 5¼ in. These units are rated for 200 milliamp, with a range of 125-325 v, dc, for Models

(Continued on page 318)



Belt vibration is a design headache . . . eliminate it by specifying Veelos!

1 This test proves Veelos V-belts cut vibration up to 90%

Why chance running into vibration troubles when Veelos V-belts stop belt vibration before it starts. Particularly in designing for air conditioning, ventilating, refrigeration and precision equipment where belt vibration and noise are costly factors . . . *you owe it to yourself to see the Veelos Vibration Test* (above), before you specify. This test proves Veelos cuts vibration up to 90% over any belt you're using. The vibration story can become a big factor in selling your machines. With Veelos Belts you *assure* your customers of less bearing wear, less spoilage and less downtime.

2 Specify Veelos for a smoother-running drive

Ordinary V-belts have varying spots of density, due to their construction, which throw them out of balance. Veelos Belts are absolutely uniform; every stud and link identical; every foot of the reel is perfectly balanced. The beveled links, the machine-cut sides add up to better vibrationless performance. And by specifying Veelos, you're doing yourself a big favor . . . because your customers will be more pleased with the added efficiency of your machines. Your Veelos salesman can give you proof that Veelos outperforms any other V-belt, by test, right before your eyes.

3 Veelos allows you complete design freedom, too!

With Veelos you fit the belt to the drive, not the drive to the belt—because Veelos is adjustable to any length. You can use outboard bearings to advantage because Veelos is installed easily without dismantling any part of the machine. With Veelos you need not design for belt adjustment—no idler, no slide rail or any other belt-tightening device is needed. Simply add or delete links; that's all; no tilting or moving motors. A 15 minute demonstration shows you the many advantages Veelos offers.

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VEELOS
THE BALANCED
LINK V-BELT

Veelos is known as Veelink outside U.S.A.

For free vibration demonstration and Veelos Data Book write to:

MANHEIM

Manufacturing & Belting Company
207 Stiegel St., Manheim, Pa.

"Industrial Belt Specialists Since 1911"

See the Veelos Vibration Demonstration at the Design Engineering Show in Philadelphia — May 14-17, Booth 433

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Rear Tractor Wheel Reversible

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ELECTRIC WHEEL COMPANY

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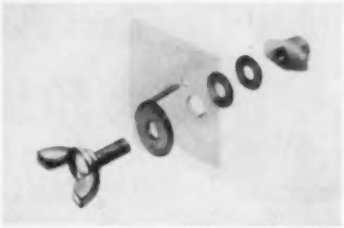
281 and 281M, and 325-515 v, dc, for Models 282 and 282 M. Size is 5¼ x 19 x 14⅛ in. depth, weight, 53 lb. Lambda Electronics Corp., 11-11 131 St., College Point 56, N. Y.

For more information—
Circle 99, inside back cover



Fastener for Small Doors

This adjustable latch can be used in material ranging from the thinnest sheets to 0.150 in. total thickness. The fastener operates with a quarter turn and requires no striker plate, since it latches against the door frame. Additional torque, applied after the fastener is engaged, pulls up the door to form a seal and eliminate vibration. Approximate weights are ½ oz for the round head and ¼ oz for the wing head styles. Available in No. 8 and No. 10 screws. Southco Div., South Chester Corp., 200 Industrial Hwy, Lester, Pa.

For more information—
Circle 100, inside back cover

Solenoid-Operated Pneumatic Valve

The d-c shut-off valve is available in normally open or closed versions with or without manual override. Statically balanced valve and sealing members are stainless steel and Teflon, some with media nylon. Pressure range

(Continued on page 322)

Planning a new product... re-designing an old one?

BOSSERT can help you develop stampings for parts or complete assemblies

When you are figuring how you will produce your new product or the old one that's getting a "face-lifting", don't overlook metal stampings, or welded assemblies of stamped or fabricated components. You can often simplify design and reduce weight, cut tooling expense and get added strength and beauty . . . at surprisingly lower cost!

Engineering service with the skill and ingenuity to project your ideas into practical, cost-saving metal stampings or complete units. Bossert design assistance in the initial stages of product development often results in a completely new approach to production and assembly . . . with substantial savings!

Complete production facilities in a modern plant with highly skilled workmen. Bossert is equipped to produce small or large, light or heavy, simple or complicated stampings and complete assemblies in any metal. Your work can be carried to any stage of completion with our extensive facilities for welding, and our precision equipment for fabricating, machining, grinding, plating, annealing and painting either parts or complete assemblies.

Delivery when you want it is important, too. Our production control system follows your order from "design to delivery," and we schedule your work to meet your requirements. Bossert, too, has reliable sources for critically short raw materials, and our customers often benefit by a saving in cost.

For complete information on our facilities, write for bulletin B-3

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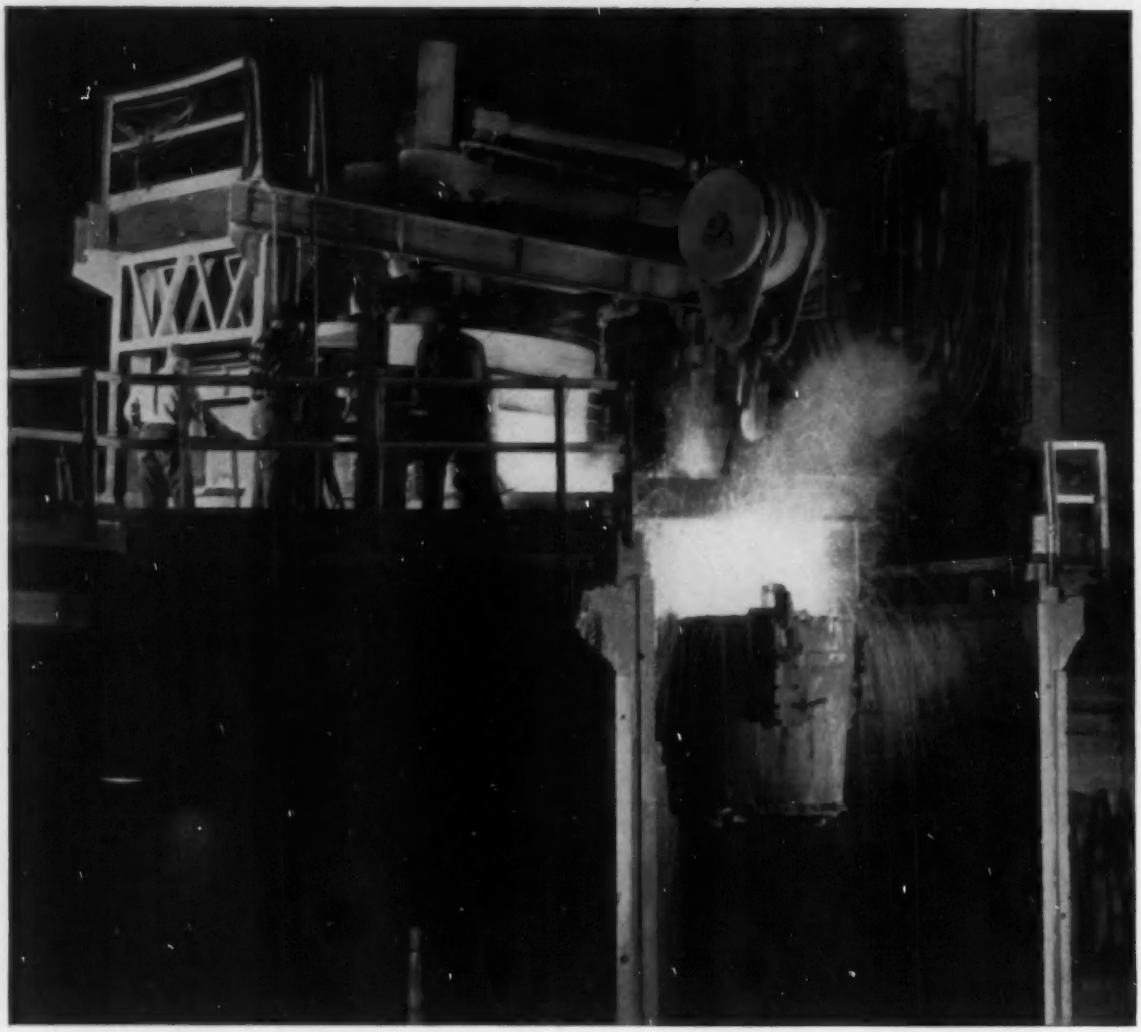
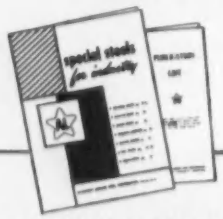


Can we pour a "cup" for you?



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ADDRESS DEPT. PE-77

Somewhere in your setup, there's a spot where one of our special alloy steel products (stainless or heat-resistant, tool or electrical) can be used to gain you a real advantage. *Right now!* It might come from reduced production, maintenance or depreciation costs. Or it might come from increased sales appeal: gaining an edge on competition in beauty, strength, service life or performance. The advantage is *there*—and our Research and Engineering Staffs are ready to help you find it. ***Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Pa.***

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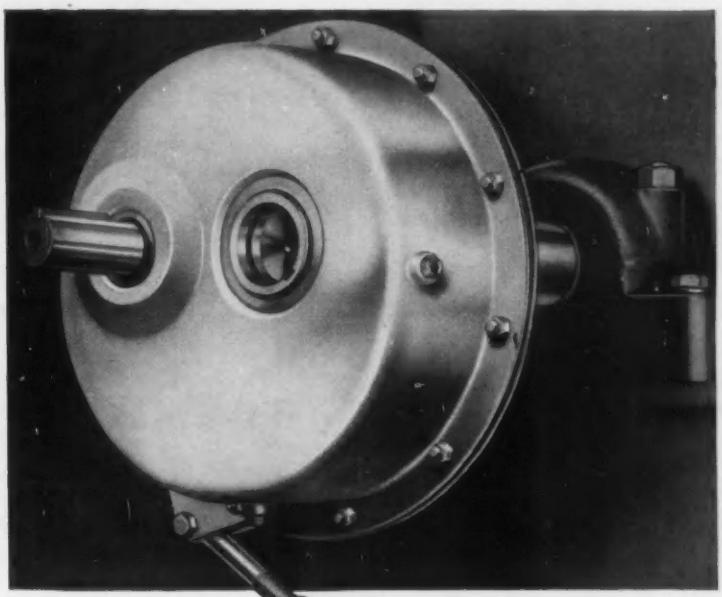

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simple-compact-rugged-efficient

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- Speed Reducers
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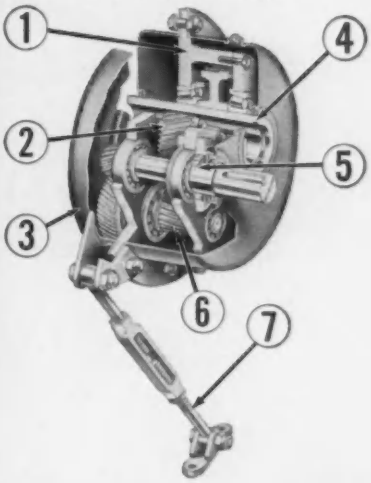
These famous FALK "In-built" factors *mean long life and dependability...*



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3 **Pressed Steel Housings,** whose sole function is to keep oil in, dirt out; easily removed for gear inspection without dismounting unit.

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6 **Positive Lubrication,** continuous direct dip of revolving elements at all speeds.

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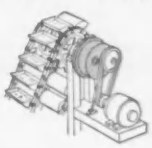
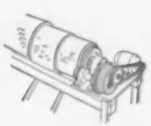
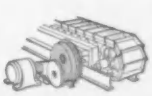
A FEW TYPICAL APPLICATIONS



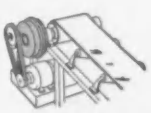
BUCKET ELEVATOR



SAND CLASSIFIER



APRON FEEDER



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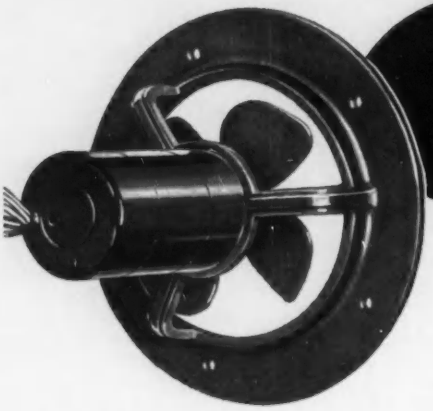

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EAD's ring-mounted fans are designed for quick, easy installation in avionic and electronic equipment. Designed for peak performance, compactness, and versatility, these units utilize blade diameters as small as 2"—with air delivery greater than many heavier blowers. These fan units, using motor sizes from 1" to 2" in diameter, are designed to meet your most rugged conditions. There is a ring-mounted fan for your requirements. Write for complete technical and performance data.

REPRESENTATIVE UNITS							
Air Delivery at 0"S.P.	Air Delivery at .5"S.P.	Blade Dia.	Voltage	Frequency	Input (Watts)	Phase Data	Basic Type Numbers
180	145	3⅛"	115	400	90	1	F4H92H
65	30	3"	115	400	15	1	F2HIT
32	15	2"	115	400	10	1	F2H90U

EASTERN AIR DEVICES, INC.

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is to 3000 psi, temperature range −65 F to 275 F. Current drain, 1.5 amp max, at 30 v, dc. National Aircraft Corp., 3411 Tulare Ave., Burbank, Calif.

For more information—
Circle 101, inside back cover

Double-Pipe Heat Exchangers

Possible applications include oil heating, oil cooling, water or steam heating, water cooling, vapor condensing, cooling of compressed air, cooling by expansion of a refrigerant gas. The unit is basically an outer shell and an inner tube with a heat-transfer surface between them. The inner tube has been machined around and along its outer surface to produce a closely packed array of spines. The spines, which remain attached to the tube, provide an integral extended surface for heat exchange. Heat transfer is said to be increased from 1½ to 5 times over conventional finned surfaces.

This heat exchanger can be obtained in outer shell diameters ranging from ¾ to 2⅝ in. OD and with inner shell diameters from ½ to 1⅜ in. ID. Lengths up to 20 ft can be provided. Any combination of metals may be used. Heatron, Inc., 333 Eberts Lane, York, Pa.

For more information—
Circle 102, inside back cover

Two-Piece Plastic Tube Fittings

Nylon fittings for use with either metal or plastic tubing are being made in sizes from ⅛ to ½ in. tube and pipe sizes. Temperature range is from −70 F to 295 F.

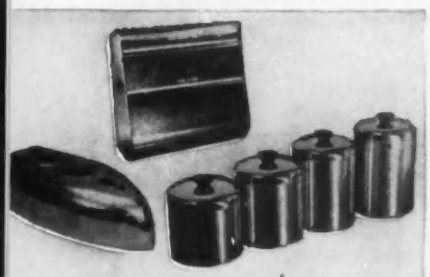
The fitting's nut has a molded in-

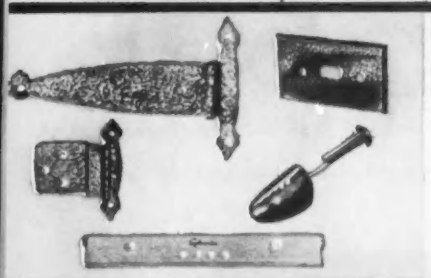
(Continued on page 326)

Puzzled About Design?

TO CHANGE THE Style

CHANGE THE STEEL





SWITCH TO *Sharonart*

If your product is made of metal that must have eye appeal, you should know about *Sharonart*—Sharon's amazing new surface rolled patterns in steel. May be painted or plated.

Many of the nation's leading product designers are already including these handsome patterns in their products of tomorrow. It isn't necessary to alter the design of your product to achieve a new look—simply change the style by changing the steel.

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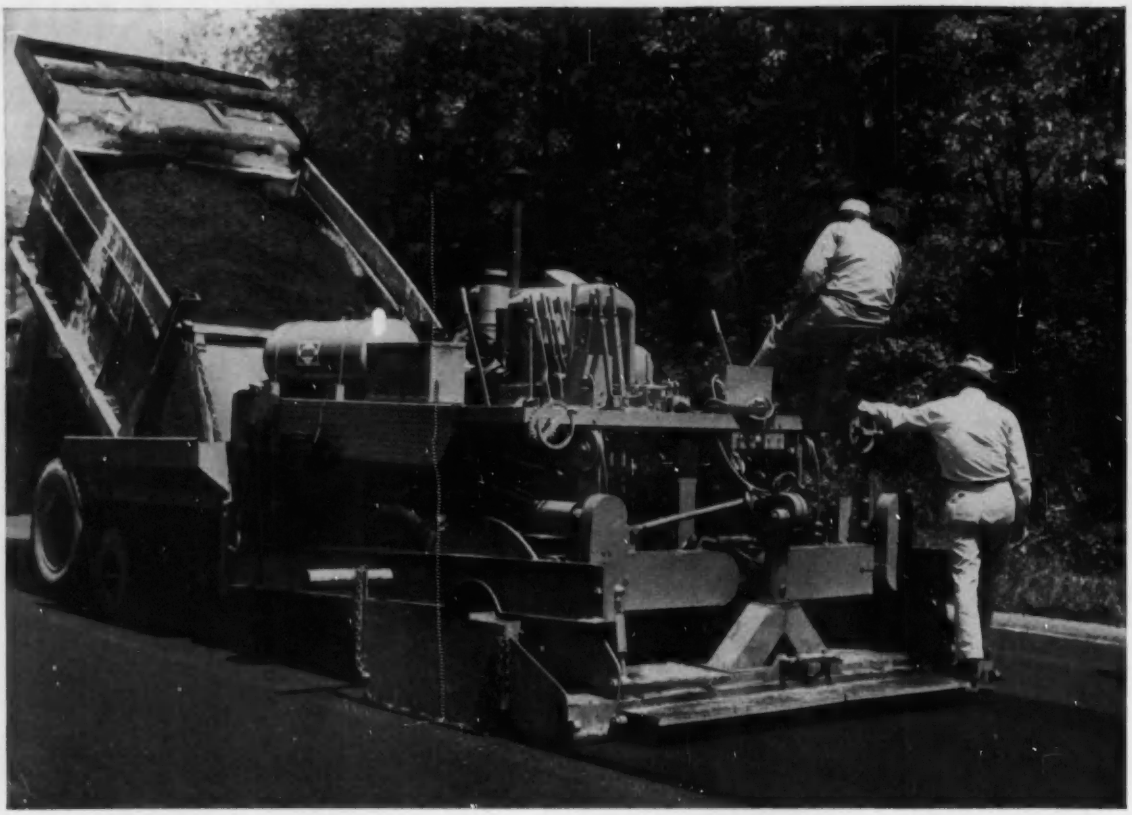


Blaw-Knox Bituminous Paver Finisher

200 tons an hour

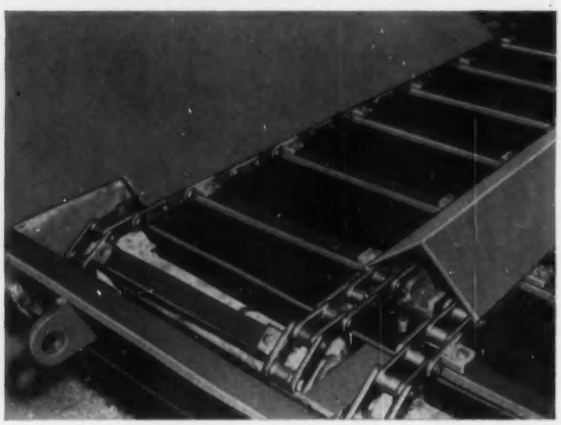
is laying a lot of pavement and

Jeffrey chain helps!

That's 48 lineal feet per minute... the pace maintained by this Blaw-Knox paver finisher on an airbase in Florida. Two Jeffrey chain conveyors carry the asphalt from the 10-ton hopper to the gates and screed, which assure smooth spreading even at this high speed.

You'll find Jeffrey chain on many manufacturers' products. It powers main and auxiliary drives, or serves on conveyors feeding materials into and out of their machines. Jeffrey chain is put there because these companies know they can depend on its accuracy and high quality. Good reasons for your asking for Jeffrey chain, too!

Whatever your power transmission or conveying problem, it will pay you to ask the nearby Jeffrey distributor for his recommendations. Or write The Jeffrey Manufacturing Company, Columbus 16, Ohio.



One of the two Jeffrey chain conveyors which keeps asphalt moving through this machine.

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CONVEYING • PROCESSING • MINING EQUIPMENT
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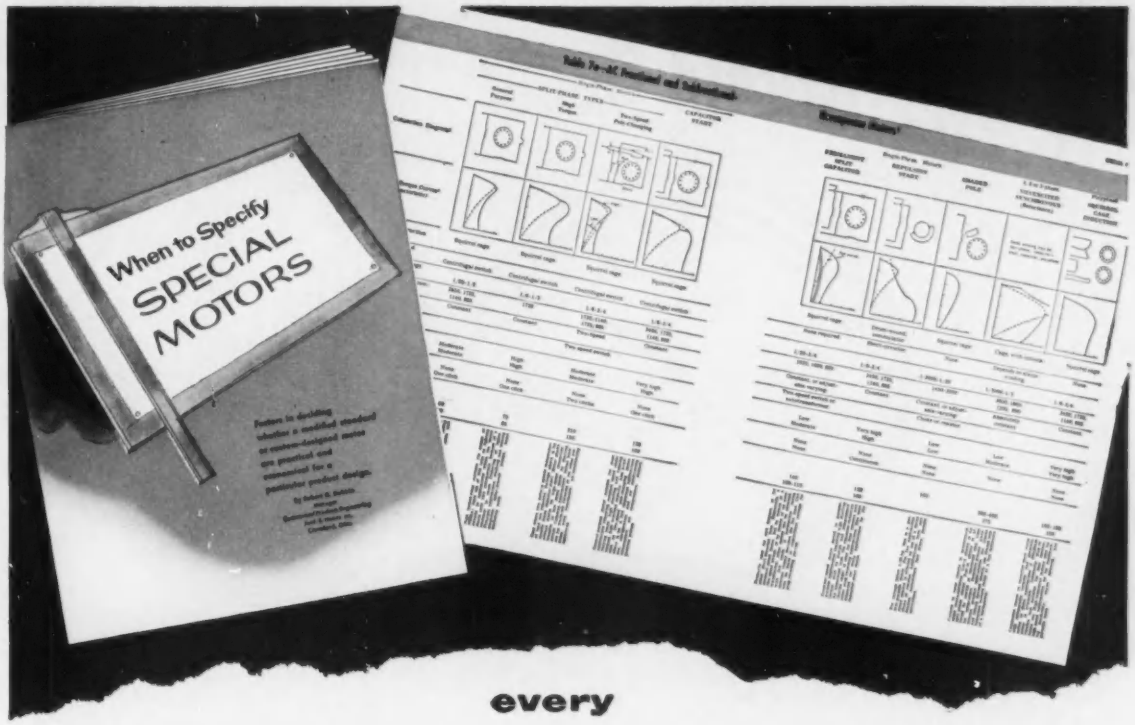

every

DESIGN ENGINEER

will want a copy of this free booklet

Here's a valuable 20-page booklet that will simplify your product design problem of deciding when you should specify special motors. It's a comprehensive handbook you'll want to keep on file for ready reference.

The booklet is an excellent guide to (1) the necessary steps in deciding whether a motor should ultimately be standard or special, and (2) the economics of motor modifications, so motor costs may be estimated at an early stage in design. It answers these basic questions:

1. What must the motor do?
2. Should a standard or special motor be used?
3. What modifications are needed?
4. Are the modifications economical?

In addition, you'll find informative technical data including charts, tables, drawings, specifications and interesting case histories... all the major factors to be considered in answering your most searching questions about motors in connection with product design.

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an ACCO product

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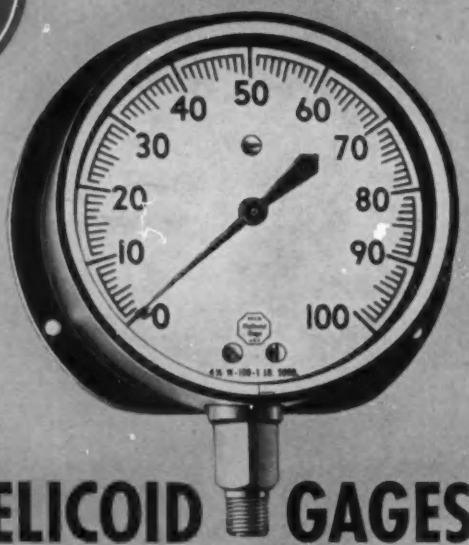

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HELICOID Gages are pressure instruments of extreme precision and long, trouble-free service with minimum maintenance. Have no gear teeth to wear out.

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Acalay square flush case

Helicoid Chemical gage

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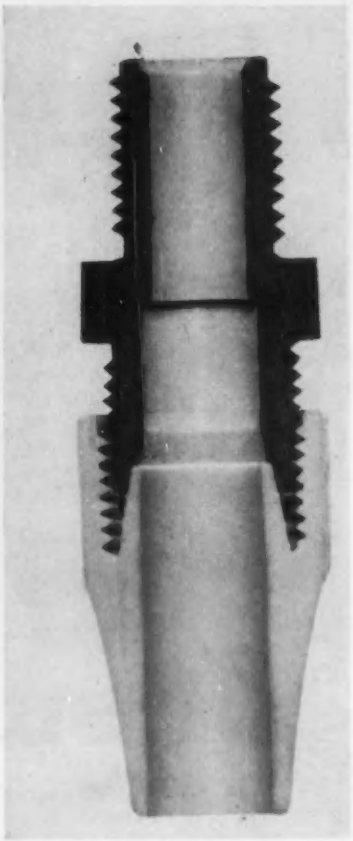


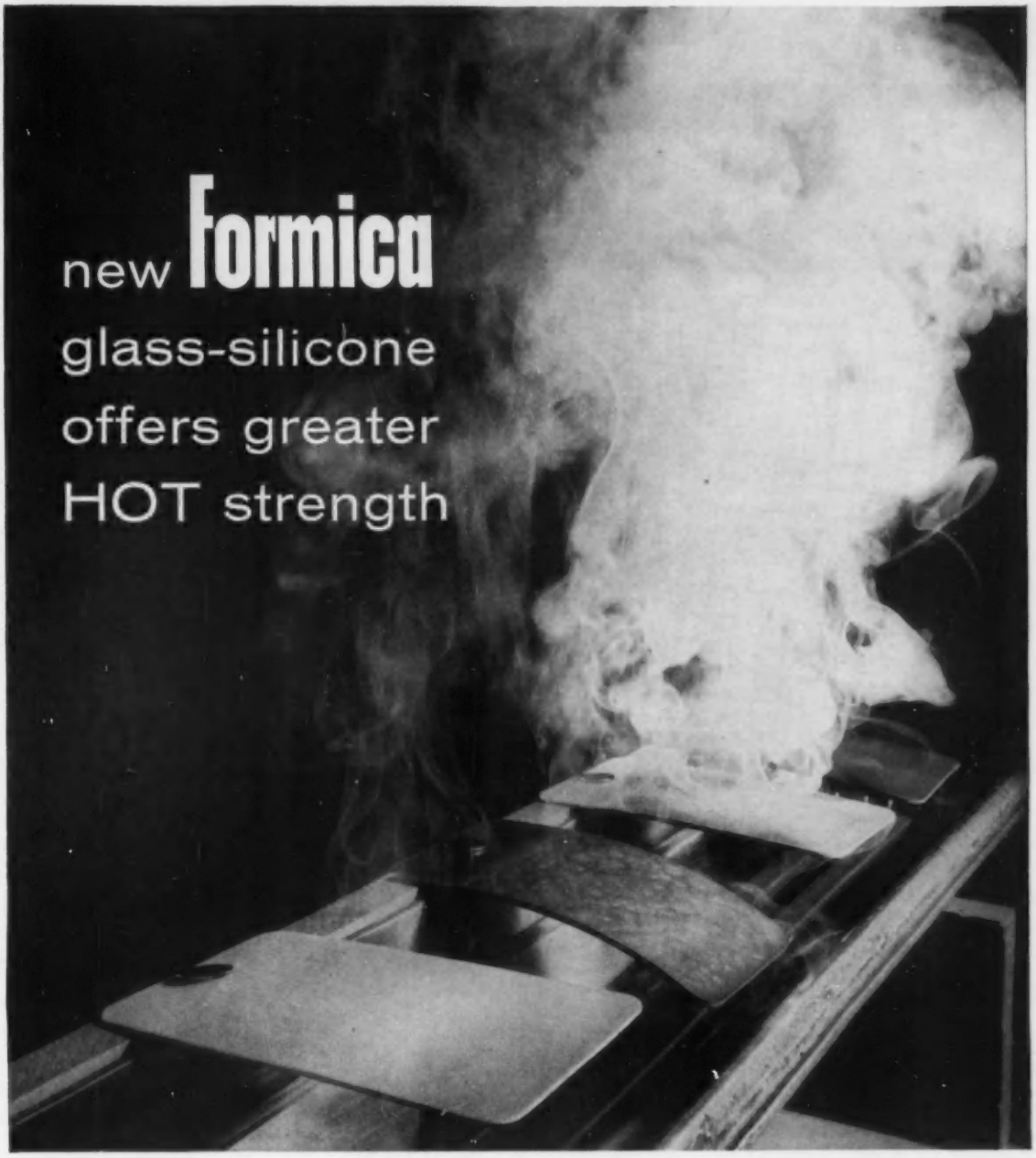
tegral ferrule. This compresses against the tube or pipe to form a flareless, vibration and leakproof seal, up to 500 psi. Thomas Associates, Inc., 4607 Alger St., Los Angeles 39, Calif.

For more information—
Circle 103, inside back cover

Rectangular Meters

These $4\frac{3}{8}$ in. meters are said to have an accuracy of $1\frac{1}{2}$ per cent and are available in a-c and d-c models. These meters are made for semi-flush panel mount applications and are supplied with or without self-illumination. An

(Continued on page 330)



New Formica G-7-2 silicone offers five characteristics for broader application:

1. Greater hot strength.
2. Lower moisture absorption.
3. Lower wet power factor.
4. Larger and thicker sheets (up to 36″ x 72″ x 2″).
5. Uniform creamy white color.

The photo above dramatically demonstrates the outstanding hot strength property of Formica's new G-7-2. A withering blast from the lab heater causes three ordinary laminated plastics to smoke, char, blister and bend. But G-7-2 comes through this grueling test unmarked, its mechanical and electrical properties virtually unaffected.

G-7-2 is approved under military spec MIL-P-997-B, type GSG.

The unusual properties of G-7-2 are especially useful in guided missiles, radar, radio and tv, motors and generators and other electrical/electronic applications. Recommended for printed circuitry. For complete information, send today for free G-7-2 data sheets. The Formica Co., 4676 Spring Grove Ave., Cincinnati 32, O.

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1st choice in laminated plastics

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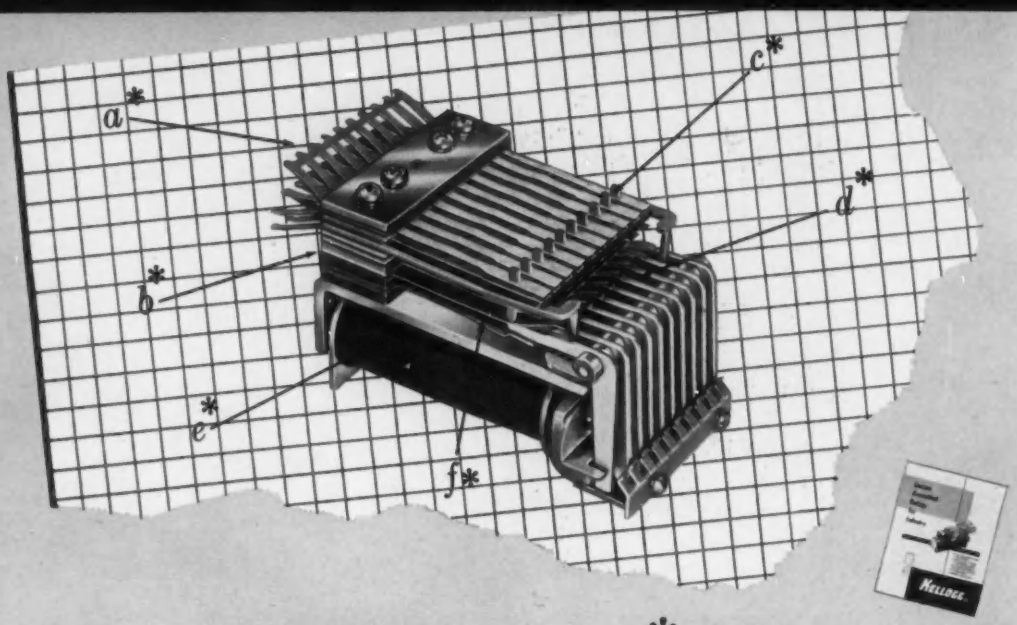
Research • Customer stock service

58 years of know-how gives you complete service data + designs that cut costs in production



We have been making and improving relays for more than 58 years. The use of these relays in our own equipment has helped to make Kellogg the leader in the independent telephone field.

A typical example is this sequence relay, "the Kellogg Magnetic Impulse Counter." This unique counter eliminates sliding contacts, mechanical rachets, etc. . . . the counting sequence is controlled electromagnetically, with relay-type contacts used throughout. Production advantages include: simplified circuitry, reduced size, lower cost and longer life.

You can save design time and cut production costs because our intimate experience as a relay-user, as well as relay-maker, enables us to develop relays that are rated to meet your requirements . . . build them to stand up in your equipment, for a lifetime of service.

* *For the A.B.C.'s of the Magnetic Impulse Counter and other Kellogg relays use the attached card to send for this Kellogg Relay Bulletin.*

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SS-102

Sandvik's wide range of sizes and grades gives you a better chance of getting a steel that fits your application "like a glove".

You see, Sandvik's Catalog is literally a bookfull of answers to specialized steel requirements. It lists hundreds of sizes in various analyses of both cold rolled and bright annealed steels and hardened and tempered steels. Take a look. You can probably put your finger on the size, finish and physical performance that's exactly right for you.

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- **Polished bright, yellow or blue.**
- **With square, round or dressed edges.**
- **Wide range of sizes in stock—also slitting facilities available.**

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FERROUS AND NON-FERROUS CENTRIFUGALLY CAST ROLLS, SLEEVES, TUBES, LINERS, CHUTES, RETORTS, RINGS, BUSHINGS, BEARINGS, ETC.

Sandusky Foundry technicians and engineers are constantly developing means of producing better ferrous and non-ferrous centrifugal castings. Experienced production personnel, the latest in product control, extensive field testing and laboratory research assure close grained, sound castings of maximum strength, added to extreme resistance to heat, corrosion, and abrasion.

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Look to Sandusky as an organization of specialists with the answers to your problems with the finest of centrifugal castings. ALWAYS SPECIFY CHIEF SANDUSKY.

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FERROUS AND NON-FERROUS

SANDUSKY FOUNDRY AND MACHINE CO., Sandusky, Ohio

external zero adjust is provided in all cases. Hickok Electrical Instrument Co., 10552 Dupont Ave., Cleveland 8, Ohio.

For more information—
Circle 104, inside back cover

Battery for Stationary Power Applications

A line of batteries with higher instantaneous discharge rates are made in heat-resistant polystyrene jars. They retain the basic Plante positive plate.

Insulation or spacing between plates of opposite polarity consists of molded one-piece polystyrene dowels and microporous rubber separators. The dowels accomplish perfect alignment between plates and greater access of electrolyte to the positive plate, resulting in better electrical characteristics. Dept. M, Exide Industrial Div., Electric Storage Battery Co., Box 8109, Philadelphia 1, Pa.

For more information—
Circle 105, inside back cover

D-c Power Supply

A power supply unit has voltage regulation, null ripple factor, and power handling capacity of a type to allow its use as a power source for strain gage bridge circuits whose a-c outputs are fed into high-gain amplifiers and recorded, or for other unstable applications. Regulator of conventional design contains an isolating transformer, a full-wave rectifier stage, filtering, and an electronic regulating stage. This pre-regulator furnishes a moderately well-regulated and filtered d-c output to a super-regulator stage

(Continued on page 334)

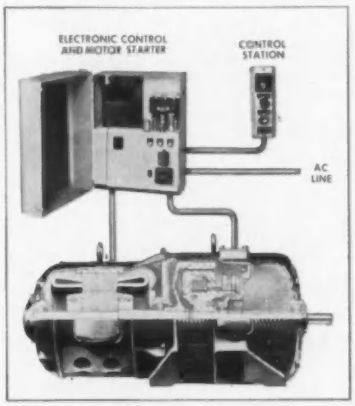
DYNAMATIC® ELECTRONIC CONTROLS

Can Solve Your Adjustable Speed Problems

Dynamatic electronic controls with their simplicity, low maintenance, easy accessibility, and small space requirements, when used with Dynamatic Eddy-Current Drives, provide the solution to most adjustable speed drive problems.

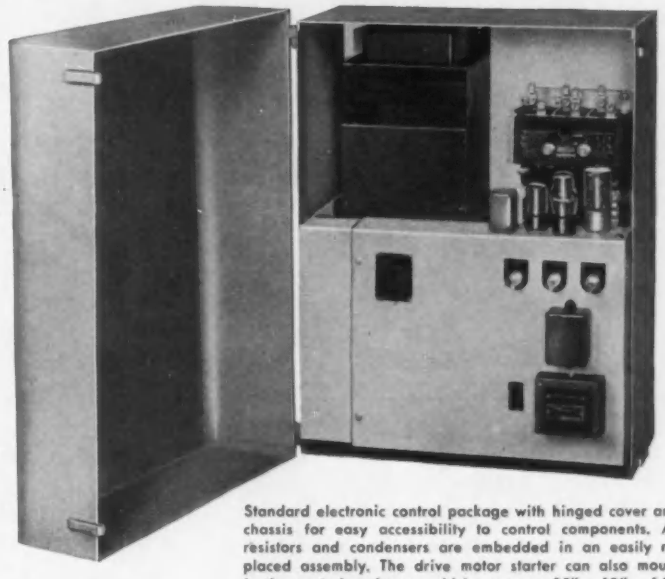
The excitation required by Dynamatic eddy-current equipment is of very small magnitude compared to the drive capacity. For example, a 440 watt control is capable of controlling the torque or speed output of a 400 HP drive. Control and excitation power is taken directly from AC lines without the need of cumbersome and complicated convertors, with their installation, ventilation, and maintenance problems.

Since the control elements have a very high amplification factor, even the largest couplings may be easily and conveniently controlled with small adjusting potentiometers.



The small illustration shows the minimum of typical components necessary to obtain adjustable speed with Dynamatic eddy-current equipment. Speed regulation requirements on the order of 1/10 of 1 per cent of drive top speed are easily and economically accomplished with suitable control modifications. With low powered reliable electronic components, requirements to suit almost all drive problems are easily met without appreciably increasing the cost or size of the control components.

The following outline of operation will indicate the many advantages of this Dynamatic control equipment.



Standard electronic control package with hinged cover and chassis for easy accessibility to control components. All resistors and condensers are embedded in an easily replaced assembly. The drive motor starter can also mount in the control enclosure, which measures 25" x 19" x 14".

Direct current excitation applied to the Dynamatic Drive coil modulates the strength of the magnetic fields and consequently, the amount of torque developed at any rate of slip between the rotating input and output members. So that the drive may satisfy load and speed demands, this direct current must be varied automatically.

Because of the drive's small power demands, rectification of easily available alternating current to direct current is a simple procedure. A gas-filled thyratron tube is all that is needed to accomplish the conversion from AC to DC. A rectifier used in conjunction with the thyratron tube, plus the highly inductive eddy-current drive coil, provides a smooth flow of direct current as required by the drive.

To obtain desired performance, a means of varying the amount of current to the drive coil must be provided. The thyratron tube provides this function in that the grid of the tube, influenced by an AC rider wave imposed upon the DC grid voltage, permits a smooth change in drive coil voltage from zero up to the available maximum.

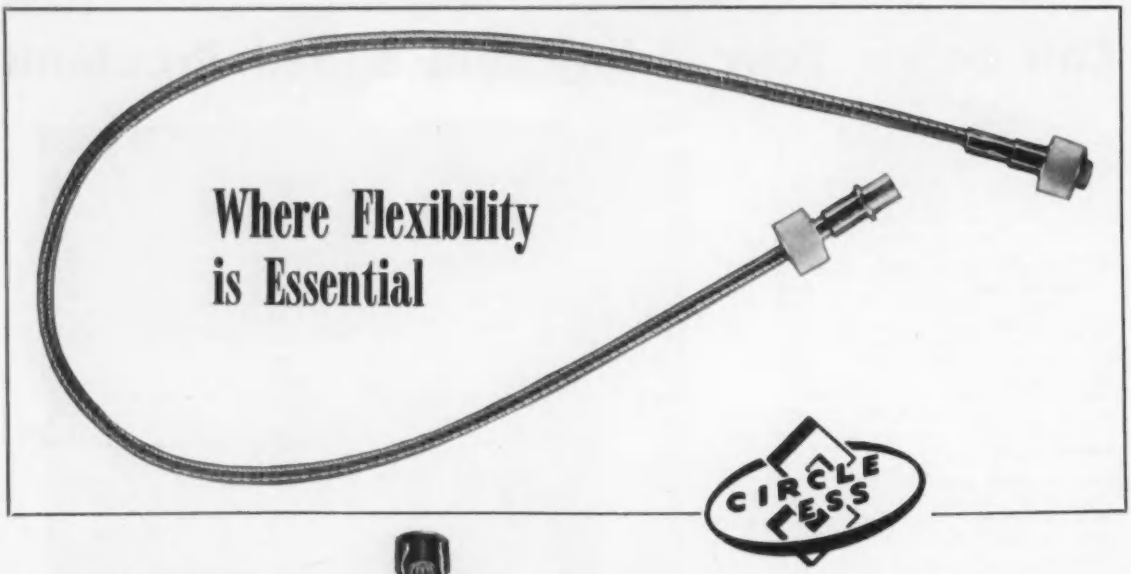
A permanent magnet alternator, driven by the output shaft of the Dynamatic Drive, generates a voltage in direct proportion to speed. This voltage directed to the electronic control is utilized to maintain pre-set speed. With a reduction in load, speed tends to increase, but the generator signals the control so that the drive coil current decreases, slowing down the unit. Conversely, should the load increase, the drive tends to slow down so that the generator signal to the electronic control automatically increases the current, permitting the drive to return to the pre-set speed.

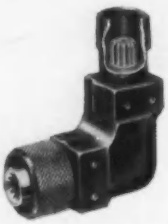
Speed and load (current) control are two of the standard types of electronic controls available. Because of the almost unlimited uses and adaptations of electronic components, many operations can be conveniently controlled, such as tension, acceleration, braking, threading, jogging, speed matching, and many others where an electrical signal can be fed to the control equipment.

Send for our 16-page Illustrated Bulletin on Electronic Controls

EATON — **DYNAMATIC DIVISION**
MANUFACTURING COMPANY
3307 FOURTEENTH AVENUE • KENOSHA, WISCONSIN

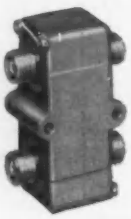
ECONOMY + PERFORMANCE





RIGHT ANGLE ADAPTER

To provide a connection for flexible shaft control where space limitations do not permit a conjunction without bending the shaft into too small a radius.

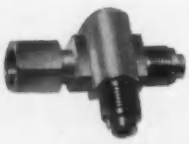


H TYPE ADAPTER

This adaptor provides three outlets, which enables the running of three units from the same power source. Ball bearing construction enables this adapter to handle heavy loads.

BALL BEARING RIGHT ANGLE ADAPTER

To provide a connection for flexible shaft control where a bend sharp enough to damage the shaft is required. Ball bearing construction enables the handling of heavier loads.



DUAL DRIVE ADAPTER

To drive more than one unit from the same power source and to provide two gear ratios from the same power source.

Flexible Shafting Offers You

Direct alignment in either remote control or power transmission.

Less working units needed in flexible shafting direct grouping.

Studier construction but lighter weight.

Write on your letterhead for our latest Flexible Shaft Manual.

F. W. STEWART CORP.

A Subsidiary of the S. S. White Dental Mfg. Co.

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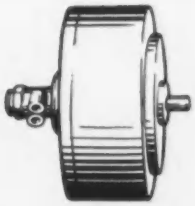
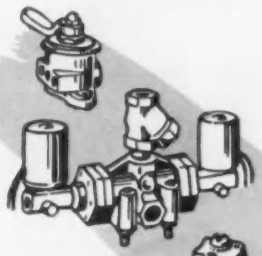
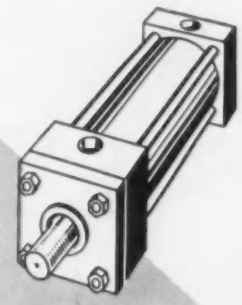
WEST COAST PLANT: 1638 So. FLOWER STREET · LOS ANGELES 15, CALIFORNIA



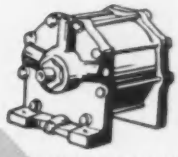
ROTATING AIR CYLINDERS



HYDRAULIC AND AIR VALVES



LOGANSQUARE AIR CYLINDERS



NONROTATING AIR CYLINDERS

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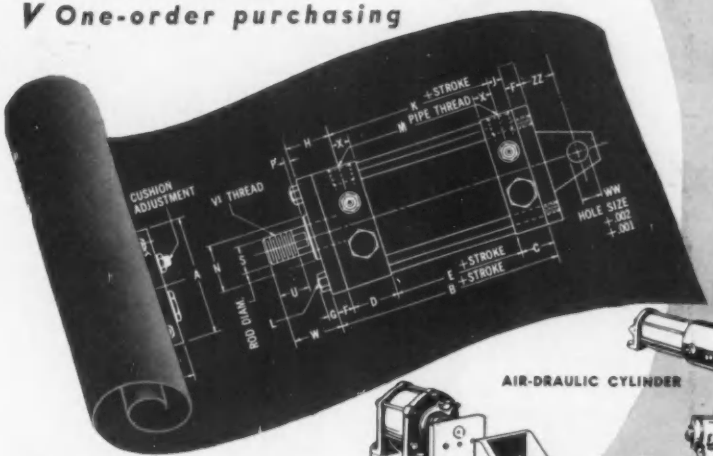
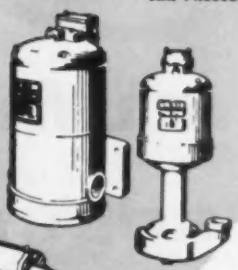
- ✓ One-manufacturer responsibility
- ✓ One-source manufacturing
- ✓ One-order purchasing

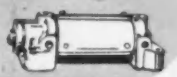
HYDRAULIC AND AIR PRESSES



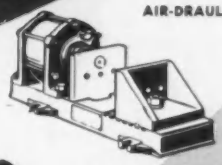


SURE-FLOW COOLANT PUMPS

AIR-DRAULIC CYLINDER



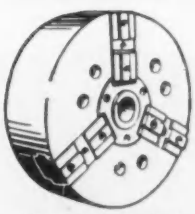
ROTOCAST HYDRAULIC CYLINDERS



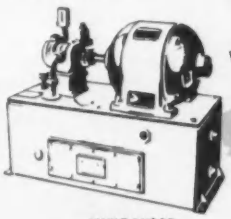
AIR-OPERATED VISES AND FIXTURES

MEMBER: Natl. Mach. Tool Builders' Assn., Natl. Fluid Power Assn.

RETURN THIS COUPON FOR FREE ENGINEERING DATA



AIR AND HYDRAULIC OPERATED CHUCKS



HYDRAULIC POWER UNITS

LOGANSPORT MACHINE CO., INC.
812 CENTER AVENUE, LOGANSPORT, INDIANA

PLEASE SEND COPY OF CATALOG:

- ☐ 100-1 AIR CYLINDERS
- ☐ 100-2 MILL-TYPE AIR CYLS.
- ☐ 100-3 AIR-DRAULIC CYLS.
- ☐ 100-4 AIR VALVES
- ☐ 100-5 LOGANSQUARE CYLINDERS
- ☐ 100-5-1 ULTRAMATION CYLINDERS
- ☐ 51 PRESSES
- ☐ FACTS OF LIFE
- ☐ 62 SURE-FLOW PUMPS
- ☐ 200-1 HYD. POWER UNITS
- ☐ 200-2 ROTOCAST HYD. CYLINDERS
- ☐ 200-3 750 SERIES HYD. CYLINDERS
- ☐ 200-4 HYD. VALVES
- ☐ 200-5 FITTINGS
- ☐ 70-1 CHUCKS
- ☐ ABC BOOKLET
- ☐ CIRCUIT RIDER

TO:

NAME _____ TITLE _____

COMPANY _____

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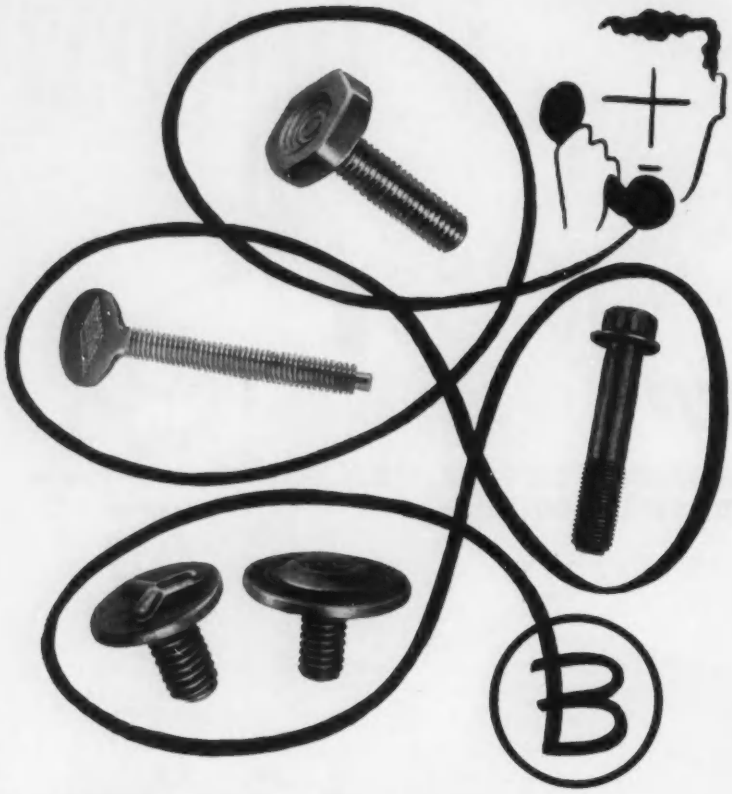
PROPERLY DESIGNED . . .
PROPERLY EQUIPPED BY

Logan YOUR DEPENDABLE "SINGLE SOURCE" For All AIR or HYDRAULIC Equipment



CALL IN *Buffalo Bolt*
for a line on
SPECIAL *fasteners*

TAKE A TIP from hundreds of manufacturers who use specially designed Ⓑ fasteners to get lower production and assembly costs and improved designs.

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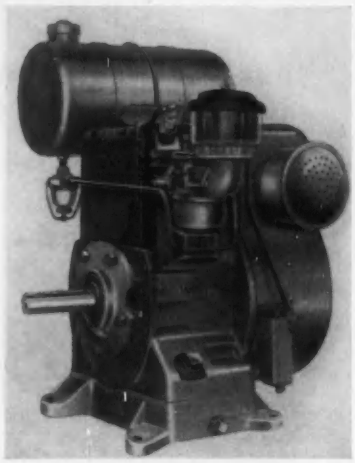
Many **GOOD** *products can be made* **BETTER** *...with* Ⓑ **SPECIAL FASTENERS**

for further and more precise refinement.

D-c output voltage is variable from 42.5 to 60 v, as required. Maximum output current, regulated 900 ma, with higher currents on request. The power supply has ±0.2 v regulation over entire current range. Commonwealth Engineering Co. of Ohio, 1771 Springfield St., Dayton 3, Ohio.

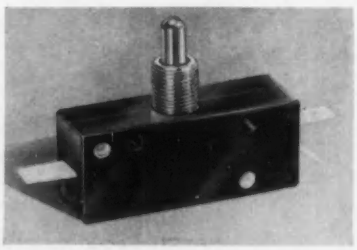
For more information—
Circle 106, inside back cover



Short Stroke 5.5 Hp Engine

A single-cylinder, four-cycle, air-cooled gasoline engine develops 5.5 hp at 3600 rpm. Weighing 86 lb, this engine has a 2¾ in. bore; 2½ in. stroke. Piston displacement is 14.9 cu in. and compression ratio is 6.25:1. D. W. Onan & Sons Inc., Minneapolis, Minn.

For more information—
Circle 107, inside back cover



Panel Mounting Switch

A switching mechanism which has a liberal overtravel, ¼ to ⅜ in., and is recommended where the actuating motion cannot accurately be con-

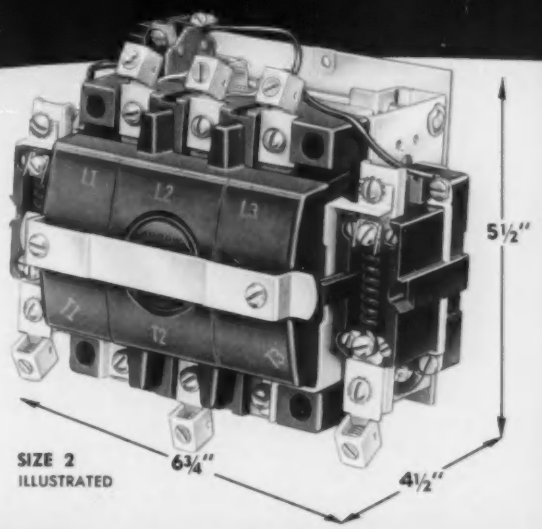
(Continued on page 337)

BY FAR THE *Finest* EVER BUILT

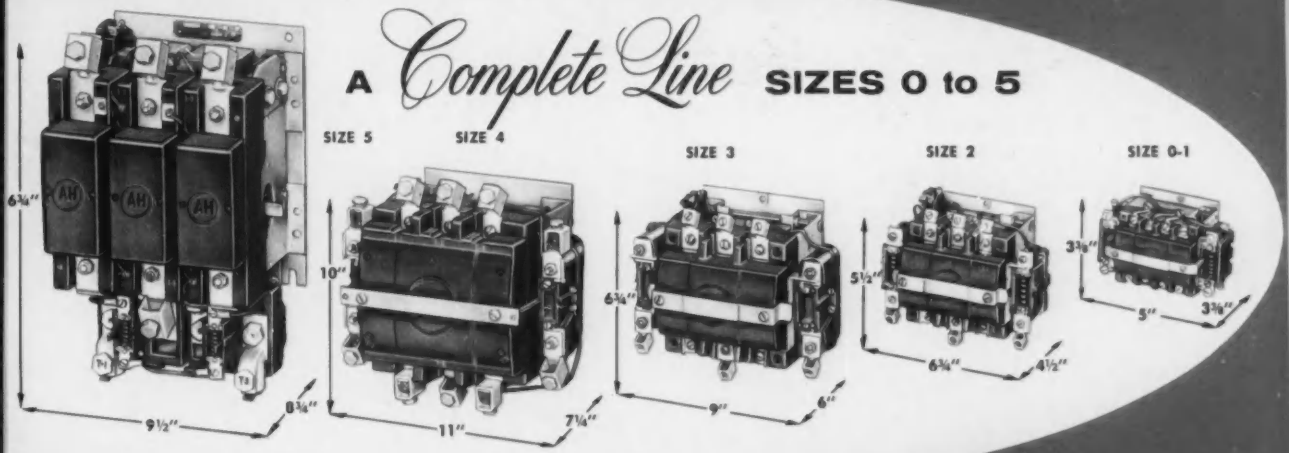
and HALF THE SIZE of Conventional Types

ARROW AH HART

MAGNETIC MOTOR CONTROLS



A *Complete Line* SIZES 0 to 5



When SMALL Space is a BIG Design Problem! . . .

Complex, modern machines call for multiple motor controls; fitting this control equipment into a reasonable area and providing ready accessibility is often a serious design problem. You can solve it easily by specifying Arrow-Hart Type "RA" Motor Controls. Radically smaller and lighter than conventional types, these starters and contactors offer the additional benefits of matchless performance, far greater dependability and much longer life.

With these ALL NEW Features in Sizes 0 and 1 . . .

- **NEW CONTACT DESIGN** . . . and a special alloy for longer life, greater resistance to welding. New metal contact carrier post.
- **RESINOX HOOD AND BASE** . . . for maximum tensile strength and added dielectric strength.
- **NEW AUXILIARY SWITCH** . . . improved, sturdy mechanism; front mounting for easier installation and removal.
- **NEW, SIMPLIFIED "RA" MECHANISM** . . . same compactness plus more efficient operation in industrial atmospheres.

LEADING DESIGN ENGINEERS DEPEND ON ARROW-HART CONTROLS TO SAVE SPACE, INSURE PEAK PERFORMANCE . . . TURN THE PAGE FOR OUTSTANDING EXAMPLES.

ARROW AH HART

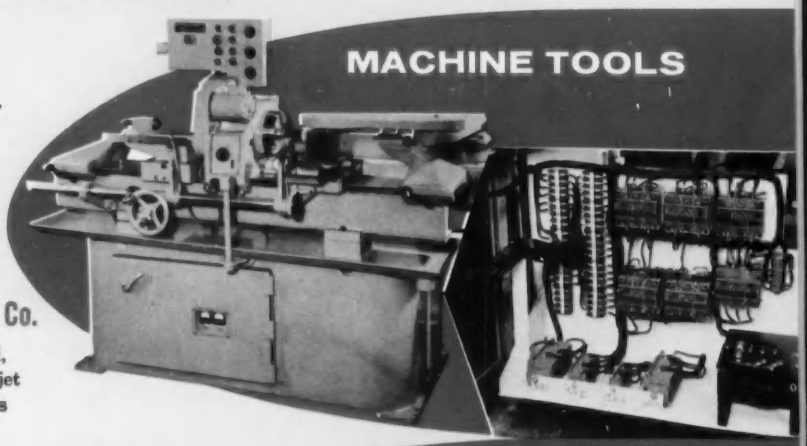
THE ARROW-HART & HEGEMAN ELECTRIC CO., Hartford 6, Connecticut

The Leaders look to ARROW AH HART *Advance Design* MOTOR CONTROLS

. . . FOR SPACE-SAVING COMPACTNESS

. . . FOR PERFORMANCE-BUILDING DEPENDABILITY

MACHINE TOOLS



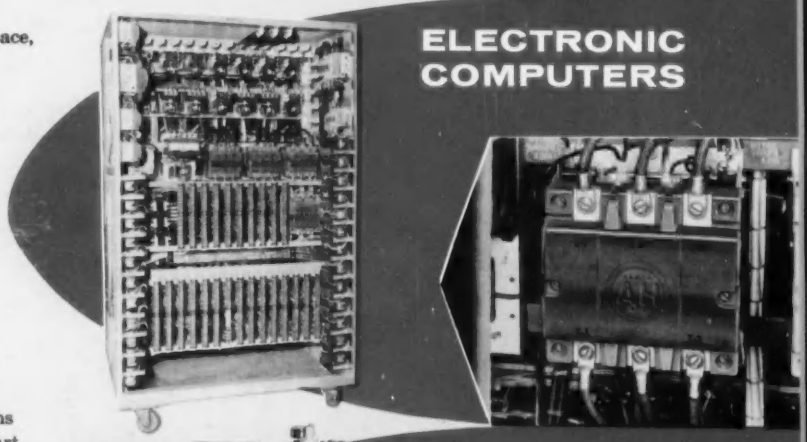
MODEL 102 AIRFOIL MILLING MACHINE

MANUFACTURED BY

The New England Machine & Tool Co.

This ingenious machine mills the original, 3-dimensional masters from which turbo jet blades are manufactured . . . does in hours a job once requiring weeks of hand work. Complexity of the operating and control mechanisms placed a high premium on space, but the 5 smaller, lighter A-H Magnetic Controls were easily mounted on an unusually compact door-back panel that swings out for instant accessibility.

ELECTRONIC COMPUTERS



TYPE 704 ELECTRONIC DATA PROCESSING MACHINE

MANUFACTURED BY

International Business Machines CORPORATION

These electronic machines are designed primarily for the use of engineers and research scientists. They are capable of performing more than 4000 multiplications or divisions per second. The 10 Arrow-Hart Contactors included in the very complicated power distribution unit were a natural choice to save valuable space. Other A-H Controls are also utilized in other parts of the machine.

HEATING EQUIPMENT

HEV-E-OIL BURNER

MANUFACTURED BY

Cleaver-Brooks Company

Simple, compact and efficient, this modern unit uses low cost, high heat heavy oils to provide economical heat for commercial and industrial buildings. Arrow-Hart Control – an "RA" Starter and a Miniature Relay – occupies little space in the small panel, leaves ample space for easy wiring.

ARROW AH HART

THE ARROW-HART & HEGEMAN ELECTRIC COMPANY
103 Hawthorn Street, Hartford 6, Connecticut
MOTOR CONTROL DIVISION

Please send my copy of the A-H Motor Control Application folder. PE

name _____

position _____

company _____

co. address _____

city _____ zone _____ state _____

ARROW-HART

MOTOR CONTROL DIVISION
THE ARROW-HART & HEGEMAN ELECTRIC COMPANY
103 HAWTHORN STREET, HARTFORD 6, CONNECTICUT

Offices, Sales Engineers and Warehouses in Principal Cities

Quality MOTOR CONTROLS • WIRING DEVICES
ENCLOSED SWITCHES • APPLIANCE SWITCHES

MAIL COUPON TODAY FOR COMPLETE INFORMATION

trolled is UL-listed. Rating is 15 amp, 125 v, ac, 10 amp, 250 v, ac, ½ hp, 125/250 v, a-c rating. Available circuits include single-pole, single-throw, normally open, or closed, and single-pole, double-throw.

This switch is for door switch, push-button switch, or limit, safety interlocking and control applications. Controls Corp. of America, 9555 Soreng Ave., Schiller Park, Ill.

For more information—
Circle 108, inside back cover

Miniature Noise Suppression Filter

Containing 14 toroids and eight capacitor sections, the filter features a noise suppression range of 0.15 to 1000 mc. Astron Corp., 255 Grant Ave., E. Newark, N. J.

For more information—
Circle 109, inside back cover

Solder-Flux Paste in Squeeze Bottle

This product is a special combination of high strength tin-lead solder and chemically active flux, suspended in a unique agent that assures free flow of the creamy mixture regardless of how long it remains in the bottle. It is said to be able to join, tin and sweat copper, brass, steel, nickel, bronze, zinc, Monel, silver and most other metals, except aluminum and magnesium. Any form of heat is adequate—soldering iron, acetylene or compressed air torch, furnace, propane, bunsen burner. The paste is available in 1 lb and ¼ lb sizes. Anchor Metal Co., Inc., 244 Boerum St., Brooklyn, 6, N. Y.

For more information—
Circle 110, inside back cover

Servo Motor-Generator

A high-speed, high-temperature servo motor tachometer generator has a no-load speed of 19,600 rpm and is capable of continuous operation at 140 C. Inertia is 2.85 gm-cm². The device consists of a Size 11, two-phase, two-pole servo motor and a drag cup-type tachometer integrated into unit measuring 1.03 x 2.156 in. long and weighing 4.6 oz. The motor portion

(Continued on page 339)

GIVING YOU

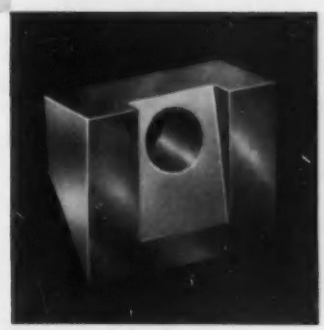
...the best and most modern!

Bunting today covers a new area in the engineering and manufacture of bearings and machine parts. To the traditional line of Bunting Cast Bronze Bearings and parts is added up-to-date, soundly established facilities for engineering and manufacturing bearings and parts made of Sintered Powdered Metals.

In an entirely new plant with the very latest equipment, Bunting now attains the position in the Sintered Powdered Metals field which it has long held in the field of Cast Bronze Bearings.

A competent group of Bunting Sales Engineers in the field and a soundly established Product Engineering Department put at your command comprehensive data and facts based on wide experience in the designing and use of Cast Bronze and Sintered Powdered Metal Bearings and parts.

MAY *is* NATIONAL WATER SYSTEMS MONTH



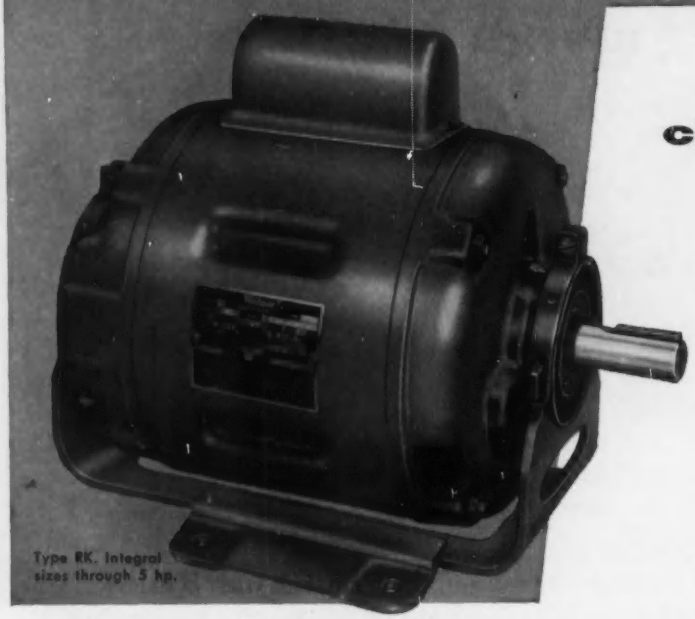
Write to our Product Engineering Department in Toledo, or consult our nearest Sales Engineer.

Bunting®

BUSHINGS, BEARINGS, BARS AND SPECIAL PARTS OF CAST BRONZE AND POWDERED METAL

The Bunting Brass and Bronze Company • Toledo 1, Ohio • Branches in Principal Cities

WAGNER ELECTRIC MOTORS...THE CHOICE OF LEADERS IN INDUSTRY



Type RK. Integral sizes through 5 hp.

choose these smaller, lighter, motors... for modern equipment

For years Wagner motors have been the first choice of many leading manufacturers of air conditioners, refrigerators, freezers, water pumps and motor-driven tools. They meet the requirements of many other similar applications because of their high starting torque and low starting current.

Now these Wagner motors are lighter in weight and smaller in size. This means that you can design smaller motor housings—build lighter motor mountings. Wagner motors are easier to handle and easier to stock because they take up less space.

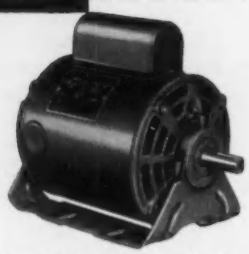
And these motors offer low maintenance costs—only a minimum of servicing is required—they give many years of reliable service with unusual freedom from vibration and noise.

Available in repulsion-start or capacitor-start types —open or totally-enclosed—sleeve or ball bearing—with rigid or resilient bases or machined endplates for flange mounting. Write today for Bulletin MU-185 which gives complete information.

A Complete Line—Single-phase and Polyphase Motors

Type RP, Polyphase fractional horsepower motors. Available in ¼, ⅓, ½, ½, and ¾ hp ratings. Rigid or resilient base—sleeve or ball bearing.

Type RA, Repulsion-start induction-run single-phase motors. For applications requiring high starting torque. ½ to 15 hp.



Type RK Capacitor-start. ½, ½, and ¾ hp . . . sleeve or ball bearings. The resilient mounting offers unusual freedom from vibration and noise.

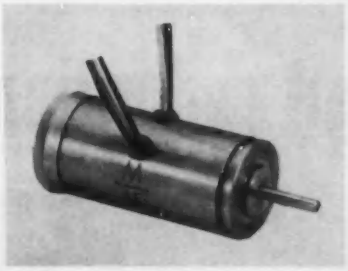
Wagner Electric Corporation
EST. WE 1891

Wagner Electric Corporation
6406 Plymouth Ave., St. Louis 14, Mo., U.S.A.

BRANCHES AND DISTRIBUTORS IN ALL PRINCIPAL CITIES

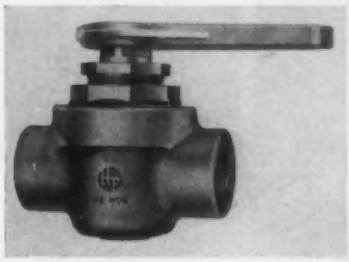
ELECTRIC MOTORS • TRANSFORMERS • INDUSTRIAL BRAKES • AUTOMOTIVE BRAKE SYSTEMS-AIR AND HYDRAULIC

M56-5



has 26 v, 400 cps input, 0.26 oz-in. stall torque minimum and 12.5 w stall wattage. The generator portion has 26 v, 400 cps excitation, 3.7 w input, 0.35 v per 1000 rpm output voltage, 23 millivolts residual voltage, 500 ohm output impedance and 1 percent linearity up to 8000 rpm. John Oster Mfg. Co., Racine, Wis.

For more information—
Circle 111, inside back cover



PVC Plug Valve

Teflon bearing buttons on the plug provide self-lubrication. A straight-through port is said to make possible unimpeded flow conditions. Adjustment to compensate for wear is possible, as well as self-indicating port positions. A nub on the bottom can be tapped for insertion of a drain plug if desired. The valve is furnished with threaded ends, or with socket type ends for solvent welding.

At present the valve will be furnished in 1½ and 2 in. sizes, to match pipe of corresponding nominal size. Tube Turns Plastics, Inc., Louisville, Ky.

For more information—
Circle 112, inside back cover

Mist Lubrication Control

The device automatically applies a controlled, pre-measured quantity of mist lubrication on open gears, chains,

(Continued on page 342)

expand metal
shrink metal
roll-form metal

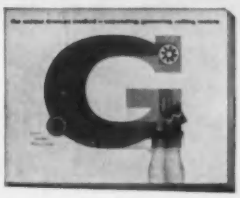
Shown:

A production sequence using GROTNES machines only (except for welding).

G

Some of Many Products Wholly or Partially Processed on GROTNES Equipment:

Blower Casings • Pails • Milk Cans • Washing Machines • Refrigerator and Freezer Cabinets • Hot Water Tanks • Agricultural and Tractor Tire Rims



GET THIS FACT BOOK
explaining the GROTNES method of cold-forming metals.

GROTNES
MACHINE WORKS, INC.
5454 N. Wolcott Ave., Chicago 40, Ill., U.S.A.
Dept. B.

BOSTON Gear

100 SPEED REDUCERS

1064 types and ratios — FROM STOCK

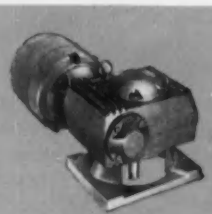
Make speed reduction

RATIOMOTORS

Output RPM
.49 to 175

Horizontal Right Angle Drive

Double Reduction Horizontal Parallel Drive



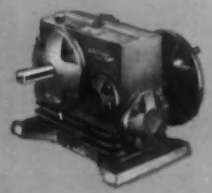
Vertical Right Angle Drive

Ratiomotors are sold also WITHOUT MOTOR as

FLANGED REDUCTORS

You buy and attach motors of your choice

Horizontal Right Angle Drive



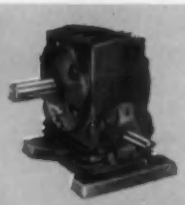
Double Reduction Horizontal Parallel Drive

Vertical Right Angle Drive

REDUCTORS

Ratios 1:1 to 3600:1

Fan-cooling optional on larger sizes



Horizontal Right Angle Drive Worm Gear over

Horizontal Right Angle Drive Worm Gear under

Vertical Right Angle Drive

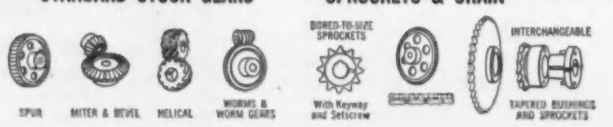
Double Reduction Horizontal Parallel Drive

Double Reduction Vertical Right Angle Drive

At the
DESIGN ENGINEERING SHOW
— see the big display and demonstration of 100 SERIES Speed Reducers,—and other new BOSTON GEAR Transmission Products. Visit the
BOSTON Gear BOOTH 514

7124 "OFF-THE-SHELF" TRANSMISSION PRODUCTS

STANDARD STOCK GEARS — SPROCKETS & CHAIN



a COST-REDUCTION feature...

in any transmission design

Double Reduction
Vertical Right Angle Drive

Double Reduction
Vertical Right Angle Drive

When you design around the 100 SERIES, you can be sure that any model you need is available promptly, — from stock. You can be sure, also, that any BOSTON Gear Speed Reducer will take top-rating in any test for operating efficiency, and lasting power economy.

You save time in planning, too, because you can get any needed information immediately in a phone call to your local BOSTON Gear Distributor's transmission specialist. Boston Gear Works, 71 Hayward St., Quincy, Mass.

New "COMBINATION" design of 100 SERIES RATIOMOTORS permits easy motor change... continued operation with spare

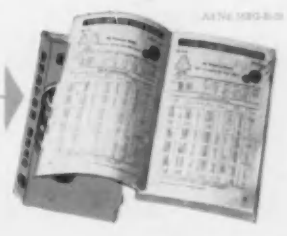
Standard end-mounted motor is easily detachable, can be changed in minutes. Gear unit is undisturbed, preserving alignment. Also, original motor can be replaced with another type (explosion-proof, etc.) at anytime.

Call your **BOSTON** *Gear*® **DISTRIBUTOR**

For nearest Distributor, look under "GEARS" in the Yellow Pages of your Telephone Book.

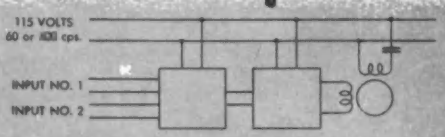
FROM YOUR DISTRIBUTOR · AT FACTORY PRICES ASK FOR CATALOG

SPEED REDUCERS — **BEARINGS** — **OTHER PRODUCTS**



NEW!
MINIATURE
SERVO
Magnetic Amplifiers

Three New AC Servo Types Available..



STANDARDIZED SERVO SYSTEMS AND OTHER STANDARD TYPES FOR AUTOMATIC CONTROL —

In addition to new lines illustrated, many standard and higher power magnetic amplifiers are available for applications involving automatic control.

CUSTOM DESIGNS FOR SPECIAL REQUIREMENTS

— we design and engineer complete servo or automatic control systems

● MAGNETIC PRE-AMP + SATURABLE TRANSFORMERS
Supply: 115 volt 400 cps.
Power output: 3.5, 6, 10, 18 watts
Sensitivity: 1 volt AC
Response Time: .03 sec.
Lowest Cost — Smallest Size
For further information request Form S493

● MAGNETIC PRE-AMP + HIGH GAIN MAGNETIC AMPLIFIER
Supply: 115 volt 400 cps.
Power output: 5, 10, 15, 20 watts
Sensitivity: .1 volt AC
Response Time: .008 to .1 sec.
Highest performance — All magnetic
For further information request Form S496

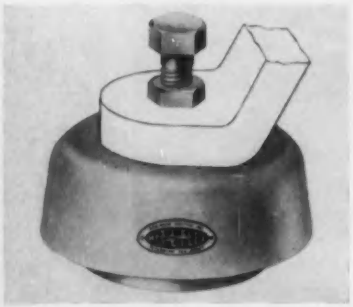
● TRANSI-MAG*: TRANSISTOR + HIGH GAIN MAGNETIC AMPLIFIER
Supply: 115 volt 400 or 60 cps.
Power output: 2, 5, 10, 15, 20 watts
Sensitivity: .01 volt AC into 10,000 ohms
Response Time: .01 sec.
Fast response at high gain
For further information request Form S499 (400 cps.); Form S497 (60 cps.)
*TRADE NAME

AFFILIATE OF THE GENERAL CERAMICS CORPORATION

MAGNETIC AMPLIFIERS · INC
Telephone: CYpress 2-6610
632 TINTON AVE., NEW YORK 55, N. Y.

cams, rollers, eccentrics, slides and ways, circular saws and similar surfaces. Lincoln Engineering Co., 5737 Natural Bridge Ave., St. Louis 20, Mo.

For more information— Circle 113, inside back cover



Adjustable, All-Metal Mount

Load-carrying capacity in three models ranges from 1000 to 10,000 lb per unit without necessity for change in the compact housing dimensions. A built-in leveling bolt and jam nut allows for quick installation on uneven floors. Maximum stability of the mounts is said to eliminate need for lagging machine to the floor. Robinson Aviation, Inc., Teterboro, N. J.

For more information— Circle 114, inside back cover

Thermistor Kit

The kits, available in three sizes, include representative units in a wide range of resistances, temperature coefficients and sizes. Mountings and styles incorporated in the sets include wafer thermistors in addition to bead, bead-in probe and bead-in-can elements. Thermistor Corp., of America, Metuchen, N. J.

For more information— Circle 115, inside back cover

Automatic A-c Regulator

This regulator operates on either 115 or 230-v lines without de-rating. Voltage change-over is accomplished in the field by switching devices requiring only seconds to operate. The control tolerance is better than 1 per cent, power rating is 6 kva, and input

(Continued on page 347)

FX

the mark of ingenuity

What's your Problem?

Fastex can help you find a cost-cutting answer to your specific mass-assembly component problem. Highly specialized production facilities and creative engineering are combined to help you realize maximum, immediate savings. Fastex specializes in the design and production of volume runs of simplified components, fastenings and multiple-part assemblies. For new approaches to improved mechanical or electrical action through plastic and metal parts, contact Fastex . . . now.

is it time...

is it space...

is it motion...

FASTEX

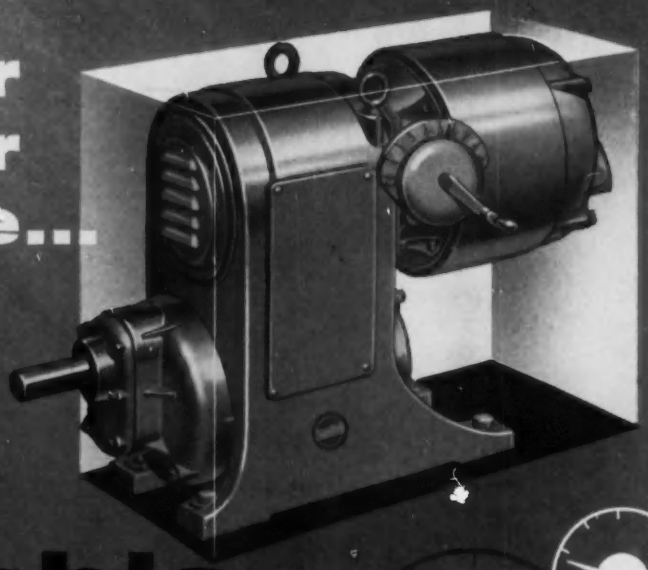
FASTEX
SHAKEPROOF

DIVISIONS OF ILLINOIS TOOL WORKS
World's Broadest Line of Mass-Assembly Fastenings

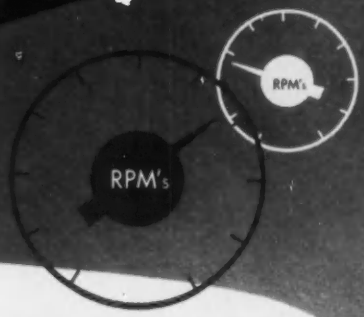
195 Algonquin Road, Des Plaines, Illinois

In Canada: Canada Illinois Tools Limited, Toronto, Ontario

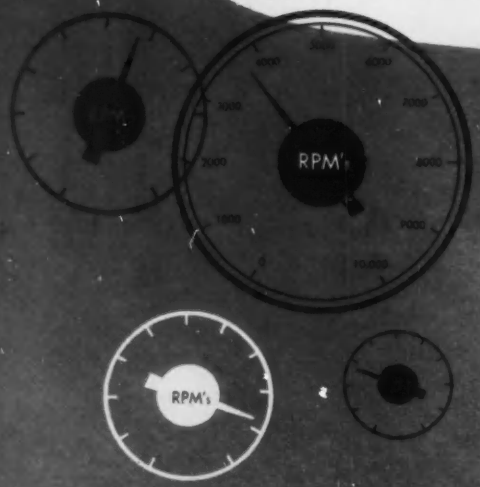
The Popular Power Package...



for Variable Speeds...



U. S. Varidrive



This popular unit combines an induction motor, variable speed drive, and gearing to give a complete variable speed power source. Often used to replace constant speed motors, it is easily installed and occupies minimum space. Rugged industrial construction gives long life even when operated under severe conditions. It requires no extraneous electronic equipment or bulky power conversion devices. Varidrives are popular with equipment manufacturers because they increase versatility and saleability of their products. Available from ¼ to 60 h.p., speed ranges cover 2 to 10,000 rpm.

U.S. Electrical MOTORS

PE N-5

U. S. ELECTRICAL MOTORS Inc.
P.O. Box 2058, Los Angeles 54, Calif., or Milford, Conn.
☐ Send Varidrive Bulletin No. F-1797.

Name_____
Company_____
Address_____
City_____ Zone____ State_____

US MOTORS

MAIL COUPON NOW

in a new car – in a used car –

STAINLESS STEEL

Sells and Re-sells!

McLOUTH STAINLESS STEEL

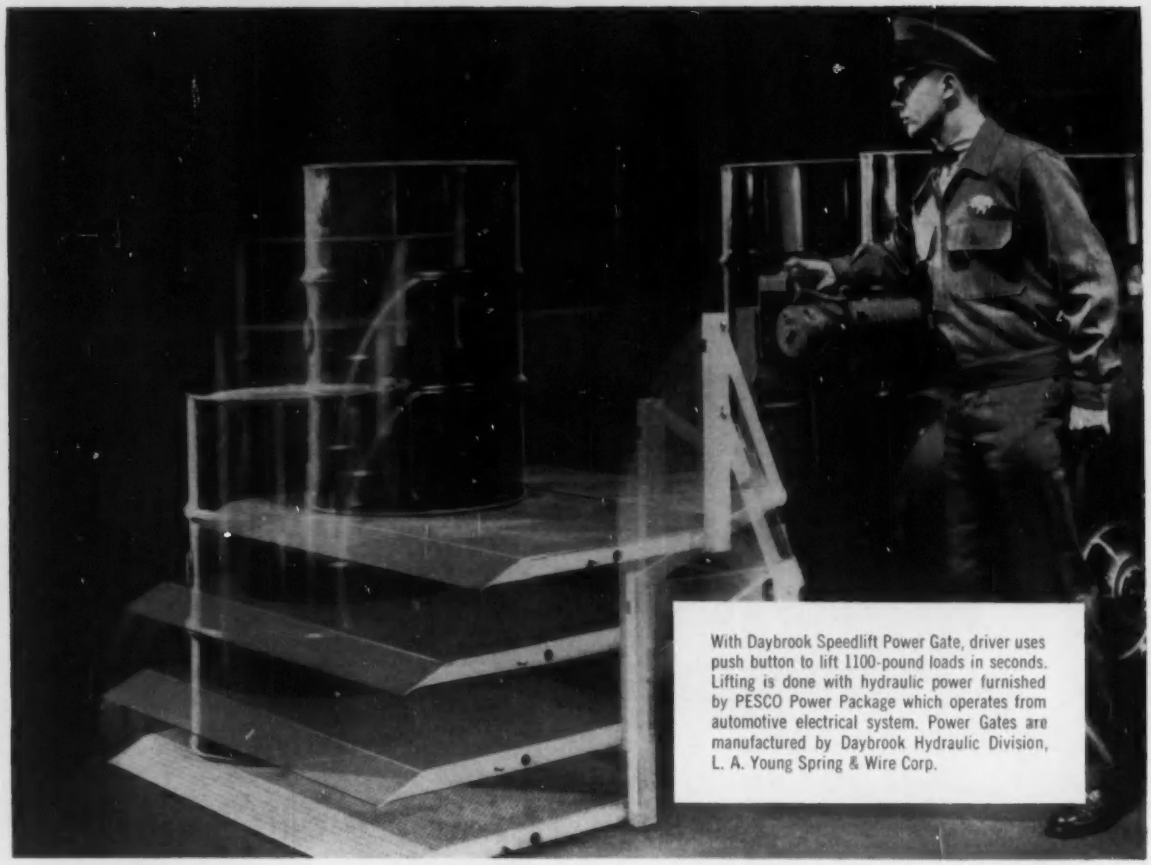
for automobiles

The Stainless Steel trim, molding and vital parts that add style and beauty to a car, inside and out, are features that help make the sale.

Stainless Steel has wide customer acceptance. It's easy to clean and keep clean. It's a tough, solid metal that will not corrode or dent and stands up to gravel, ice, salt and water.

The finish never fades and parts are easy to replace. Stainless Steel lasts the life of the car. It *sells* in a new car and it *re-sells* in a used car.

McLOUTH STEEL CORPORATION, ***Detroit, Michigan, Manufacturers of Stainless and Carbon Steels***



With Daybrook Speedlift Power Gate, driver uses push button to lift 1100-pound loads in seconds. Lifting is done with hydraulic power furnished by PESCO Power Package which operates from automotive electrical system. Power Gates are manufactured by Daybrook Hydraulic Division, L. A. Young Spring & Wire Corp.

hydraulic power at the push of a button

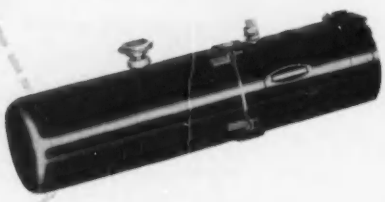
...with self-contained Pesco package

If you need to produce hydraulic power from an electrical source, investigate PESCO's line of Hydraulic Power Packages.

These low-cost units are versatile and find extensive application on tailgate loaders, lift trucks, small dump bodies, farm tractors and snow plows. They provide hydraulic flow to .80 gpm at pressures to 2000 psi from any suitable 6, 12 or 24-volt d-c source.

PESCO Hydraulic Power Packages include an electric motor, hydraulic gear pump with integral relief valve, check valve and reservoir in a single, self-contained assembly. The PESCO gear pump features "Pressure Loaded"* bearings for higher volumetric efficiency and longer service life.

Original equipment manufacturers are invited to obtain price quotations or specific information from your nearest PESCO sales engineer or write: PESCO, 24700 North Miles Road, Bedford, Ohio.



PESCO HYDRAULIC POWER PACKAGE converts electrical power to hydraulic, finds wide industrial use. Compact "package" design contains motor-driven gear pump, relief and check valves and reservoir.

See our catalog in Sweet's Product Design File

PESCO PRODUCTS DIVISION
BORG-WARNER CORPORATION
24700 NORTH MILES ROAD • BEDFORD, OHIO

Producing the Best in Hydraulic Pumps, Fuel Pumps, Electric Motors and Axial Flow Blowers

**PESCO's patented principle of gear pump construction*

range is 100 to 130 v or 200 to 260 v at line frequencies from 47 to 63 cps. The wall or floor mounted unit is 18½ x 13 x 8¾ in. deep overall. Weight is 90 lb. Electronics Measurements Co., Lewis St., Eatontown, N. J.

For more information—
Circle 116, inside back cover

Thermistor Reference Kit

The kit is provided with specification sheets covering dimensions, electrical characteristics, and temperature-resistance relationships of the rod-type thermistors. In addition, thermistor applications in electrical and electronic sensing, controlling and indicating devices are catalogued.

The dozen thermistors, each individually packaged, cover resistance ranges from 25 to 1 million ohm. Friez Instrument Div., Bendix Aviation Corp., 1400 Taylor Ave., Baltimore 4, Md.

For more information—
Circle 117, inside back cover

High Voltage Tester

A buzzer and red light signal when insulation defects or grounds are found, allowing the operator to watch the work instead of the tester. The

(Continued on page 350)

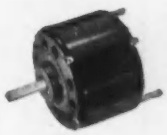
DEPENDABILITY...

General Industries
FRACTIONAL HP. MOTORS
1/40 HP to 1/1100 HP

Dependability . . . for a lifetime of trouble-free performance, is a prime factor in every GENERAL INDUSTRIES FRACTIONAL HP MOTOR.

■ For an unfaltering, dependable lifetime of service, General Industries' fractional hp. motors have no equal — that's just one reason why original equipment manufacturers have been relying on GI 1/40 hp to 1/1100 hp motors for over 25 years. They appreciate General Industries' free design consultation service and prompt deliveries, too. When you have a fractional hp. requirement, you'll find that your best bet is to . . . specify GI!

Write for complete specifications and quantity-price quotations.



MODEL B
4-pole, 4-coil shaded pole AC Induction Type

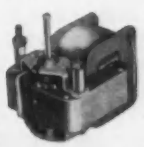
MODEL A
2-pole, shaded pole AC Induction Type

MODEL C
2-pole, shaded pole AC Induction Type

MODEL E
4-pole, shaded pole AC Induction Type

MODEL O
2-pole Capacitor Reversible Type AC only (for 6, 12, or 24 volts)

MODEL D
4-pole, 4-coil shaded pole AC Induction Type



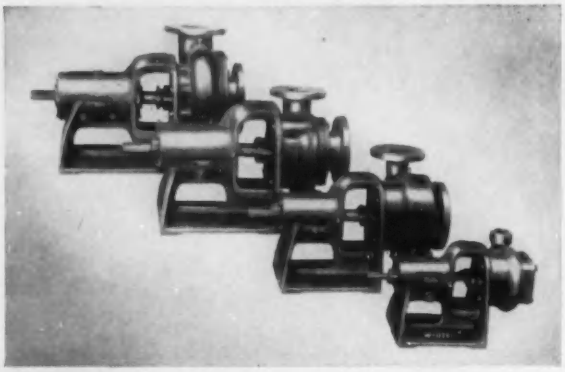
MODEL F
2-pole, shaded pole AC Induction Type

Write for Complete Specifications and Quantity - Price Quotations!

THE GENERAL INDUSTRIES CO.
DEPARTMENT GM • ELYRIA, OHIO

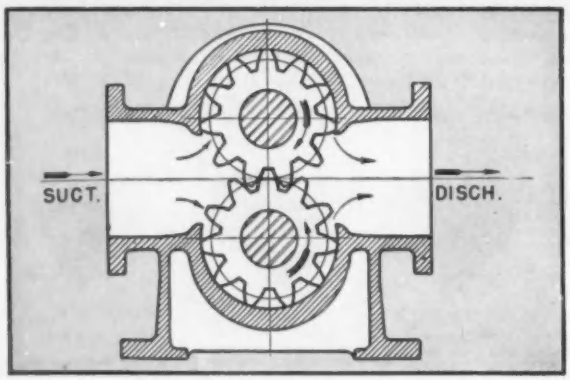
WHAT'S YOUR P.Q.*?

* Pump Quotient



Why are more and more end-suction pumps being specified? The answer's *simplification.* Industry is turning to end-suction pumps because they simplify piping (especially in process applications), need only one stuffing box, and make parts replacement easy. Get the full story on the Worthington end-suction pumps by writing to Section PC.4.8.

What is Worthite? Worthite is Worthington's "super-stainless", corrosion-resisting alloy steel containing more than 50% of the alloying elements: nickel, chromium, molybdenum, silicon, copper and manganese. The balance is mainly iron. Worthite was first introduced in 1936 and has gained wide acceptance as an excellent construction material for applications where corrosion is a problem. Worthington, of course, offers a complete line of Worthite pumps. Write for Bulletin W-350-B4.



Why are gear-type rotary pumps best for handling high-viscosity fluids? Lots of reasons. First, their large, unobstructed passages mean low entrance losses. Then, there aren't any valves or valve springs. Also, there's the flexibility in application offered by the wide speed range of gear-type rotaries. Write for Bulletin W-483-B2 for facts about the Worthington double-herringbone gear rotary pumps and vane pumps. PC.4.8

See your Worthington distributor for more information about end-suction pumps, Worthite and gear-type rotary pumps. But if you want to read up on these products before talking to him, write for our bulletins today. Worthington Corporation, Merchandising Division, Section PC.4.8, Harrison, New Jersey.

WORTHINGTON

"SPECIFY THESE WORTHINGTON STANDARD PRODUCTS ON YOUR EQUIPMENT"

Air Compressors • Pumps • Multi-V-Drives • Allspeed Drives

See the new Saw from C-B Tool Company

IT WEIGHS LESS,
COSTS LESS,
WORKS BETTER

The C-B Tool Co. Story

It was easy! Engineers from C-B Tool Company, Lancaster, Pa. and Ostuco in Shelby worked out a welded steel tubing component to replace a heavy, bulky oil reservoir and to serve as a handle for the new saw. See the difference this makes in the new Lancaster Model 400A chain saw:

- **Saves Cost—$4.25 on each chain saw!**
- **Saves Weight—3 pounds on each unit!**
- **Works better—Saw now has positive, continuous oiling instead of push-button oiling by the operator.**

Perhaps this story from C-B Tool has a message for you.

If you have trouble with see-sawing production costs and quality, Ostuco may have the answer to your problems. Unique single-source service eliminates interplant shipment, reduces error, gives better production control. See about it . . . see Ostuco! Contact the Shelby office or your nearby Ostuco Sales Engineer for details.

OSTUCO SHELBY, OHIO **OSTUCO TUBING**

SEAMLESS AND ELECTRIC WELDED STEEL TUBING
—Fabricating and Forging

OHIO SEAMLESS TUBE DIVISION
of Copperweld Steel Company • ***SHELBY, OHIO***
Birthplace of the Seamless Steel Tube Industry in America

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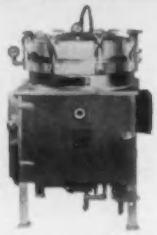
CANADA, RAILWAY & POWER ENGR. CORP., LTD.

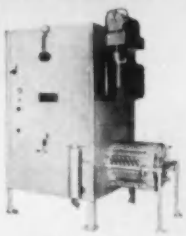
EXPORT: COPPERWELD STEEL INTERNATIONAL COMPANY 117 Liberty Street, New York 6, New York

HILCO LUBRICATING and INDUSTRIAL
Oil Maintenance Equipment
Saves Your Oil, Money and Machinery



OIL RECLAIMER

For continuous oil purification in range of 2-100 gph. Removes all solids, acids and volatile contaminants.

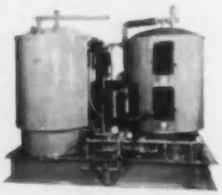


PURIFIER-RE-REFINER

For all purification in batches of from 6 to 100 gallons. Removes all solids, acids and volatile contaminants.

FILTER

Furnished in capacities from 0.1 to 750 gpm. Various cartridges available for mineral and inhibited detergent oils.



HIGH CAPACITY RECLAIMER

Combines filtration for removal of solids and sludge with vacuum vaporization for removal of solids, acids, water, solvents, fuel dilution. Furnished in standard or custom built models to 600 gph.

HILCO purification means *complete* oil purification . . .

Whenever oil is used it becomes contaminated and must be discarded or conditioned for further use. There is a HILCO to do this job for you. You can recover large quantities of oil at low cost. HILCO units are available for continuous or batch operation.

A COMPLETE LINE OF EQUIPMENT FOR RECLAIMING, FILTERING, PURIFYING AND REFINING OIL FROM . . .

- Diesel Engines
- Trucks
- Tractors
- Gasoline Engines
- Gas Engines
- Automobiles
- Buses
- Heat Treating Systems
- Locomotives
- Steam Turbines
- Steam Engines
- Air Compressors
- Vacuum Pumps
- Transformers
- Circuit Breakers
- Wire Drawing Machines
- Hydraulic Equipment
- Metal Rolling Mills
- Paper Making Machinery

THERE'S A HILCO TO DO THIS JOB FOR YOU

• CONSULTING ENGINEERS •

WRITE TODAY! FOR THE NEW HILCO CATALOG FOR COMPLETE INFORMATION AT NO OBLIGATION . . .

THE HILLIARD Corporation

198 W. FOURTH STREET • ELMIRA, NEW YORK

IN CANADA: Upton-Bradeen-James Ltd., 890 Yonge St., Toronto; 3464 Park Ave., Montreal

test voltage is shown on a large meter that is marked at 50 v intervals, so that voltage variations caused by an unstable power supply can be seen.

Small parts can be tested with the push-button prods that safely retract into phenolic housings when released; detachable test leads simplify replacement of damaged leads or prods; and any testing voltage between 400 and 2100 v, ac, is supplied by the unit. Equipped with on-off switch and pilot light, the tester plugs into any 115 volt, 60 cps outlet. Assembly Products, Inc., Chesterland, Ohio.

For more information—
Circle 118, inside back cover

Vacuum Tube Voltmeter

This battery-operated d-c voltmeter has an input impedance of over 10^{14} ohm, a grid current less than 5×10^{-14} amp and full scale accuracy within 2 per cent. The instrument has eight voltage ranges of 0.008, 0.02, 0.08, 0.2, 0.8, 2, 8 and 20 v, full scale, of either polarity.

When used with accessories, the meter measures currents as low as 5×10^{14} amp, resistance above 10^{18} ohm and voltages up to 20,000 v. Keithley Instruments, Inc., 3868 Carnegie Ave., Cleveland 15, Ohio.

For more information—
Circle 119, inside back cover

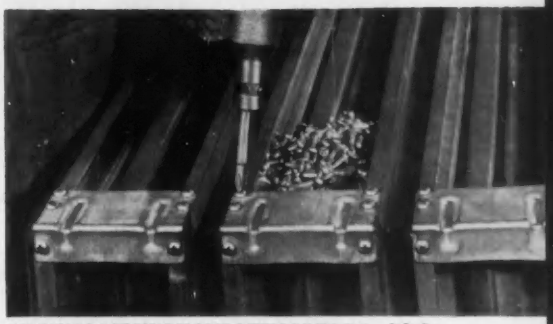
Plastic Cover Limit Switches

The purpose of this switch's transparent cover is to permit the operator to observe the contact action without removing the cover. Waterproof, the

(Continued on page 353)

Greater Production - Neater Installation with PHILLIPS CROSS RECESSED HEAD SCREWS

"OUR PRODUCTION INCREASED 50%, and probably even more since the use of power drivers made possible by Phillips head screws," says the Plant Manager of Yankee Metal Products Corporation of Norwalk, Connecticut. Phillips screws have also eliminated damage and have facilitated the ready replacement of signal lenses.



"PHILLIPS SCREWS HAVE REWARDED US with increased production, ease of operation, elimination of damage due to screw driver slippage, longer tool life, more attractive appearance, more positive gripping and more secure fastening," states Mr. Solar, plant manager of Fleet of America, Inc., makers of quality aluminum prime windows and doors.

LINCOLN, division of the Ford Motor Company, uses Phillips Cross-Recessed-Head Screws in the construction of the luxurious Lincoln automobile. The picture above shows Phillips screws being easily installed in the windshield wiper motor of the Lincoln.

MANUFACTURERS OF PHILLIPS CROSS-RECESSED-HEAD SCREWS

THE FASTENERS OF TODAY...
AND OF THE FUTURE
X marks the spot
the mark of extra quality

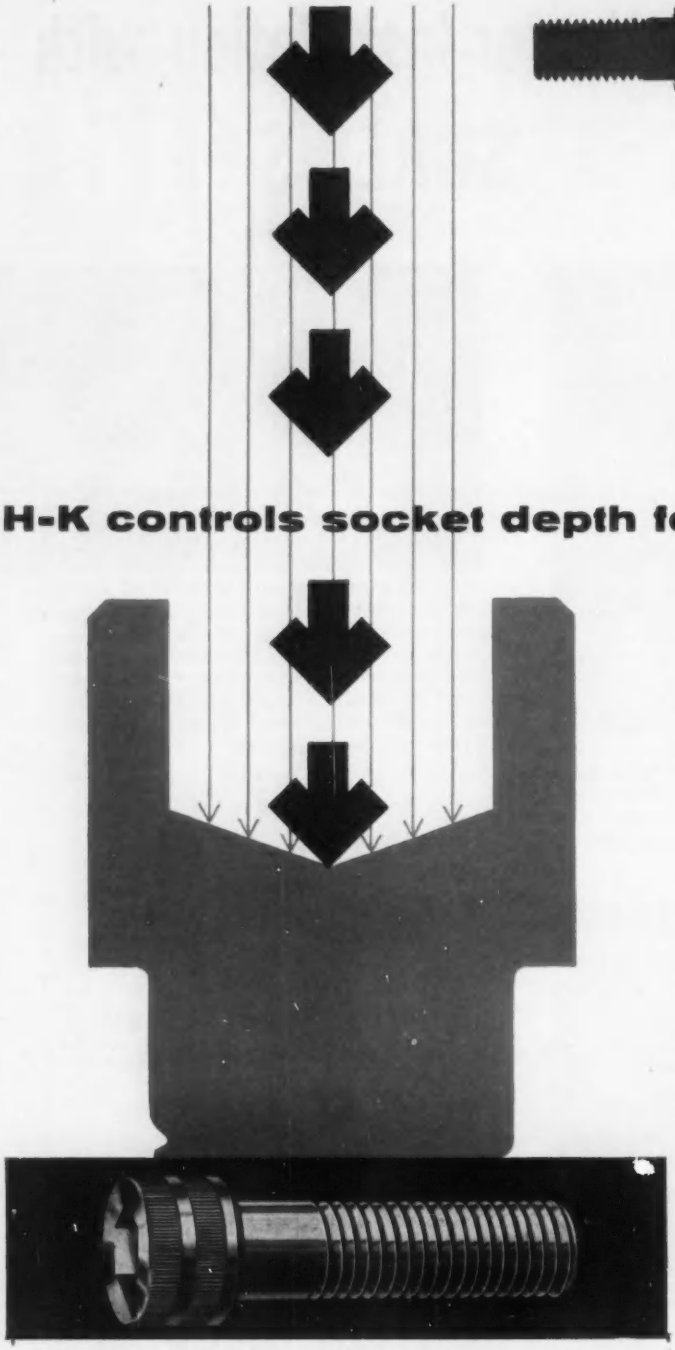
Pledged to highest standards...

The Phillips Screw manufacturers listed here cooperate to turn out a uniformly high standard of quality. As sponsors of the Phillips Cross-Recessed-Head Standards Committee they adhere to the established dimensional standards, gauges, and gauging methods which will best serve industry.

Members of Screw Research Association

American Screw Company • Atlantic Screw Works, Inc. • The Blake & Johnson Co. • Central Screw Company • Continental Screw Co. Elco Tool and Screw Corporation • Great Lakes Screw Corp. • The H. M. Harper Company • The Lamson & Sessions Company • National Lock Company • The National Screw & Manufacturing Company • Parker-Kalon Division, General American Transportation Corporation Pheoll Manufacturing Co. • Scovill Manufacturing Company • Shakeproof Division Illinois Tool Works • The Southington Hdwe. Mfg. Company • Sterling Bolt Company • Wales-Beech Corporation

INSIDE INFO FROM HOLO-KROME



THE SECRET'S IN THE SOCKET!

Holo-Krome carefully controls the socket depth. Sockets are deep enough for the hex key to get a firm, solid bite . . . yet scientifically proportioned to give maximum strength to the head of the screw. Accurate design is another plus you get when you specify Holo-Krome.

H-K controls socket depth for tougher screws!

Compare These Other H-K Features!

SHARP HEX CORNERS . . . where the hex key gets a solid grip for firmer fastening.

UNTAPERED WALLS . . . for better key fit, longer key and socket life, even tighter wrenching.

COMPLETELY FORGED SOCKET HEAD . . . no drilling or broaching—metal fibers stay intact for stronger hex sockets.

For the finest in Socket Screw products . . . for revolutionary SAME-DAY SERVICE, the name to remember is Holo-Krome!

LOOK INSIDE A HOLO-KROME SOCKET!

Send in the coupon below and we'll send you **FREE** an H-K Socket Cap Screw (we've omitted heat treating to let you get a better look at the mirror finish and sharp hex corners under the usual black finish). Look it over carefully, and see for yourself what a real difference H-K quality and skill can make!

Please send me FREE a Holo-Krome Socket Screw for my inspection.

NAME _____

POSITION _____

COMPANY _____

ADDRESS _____

CITY _____ ZONE _____ STATE _____

HOLO-KROME

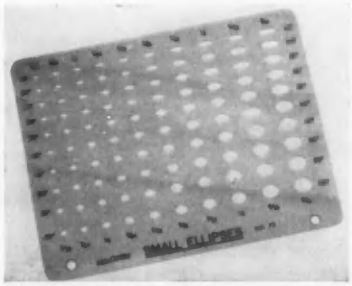
THE HOLO-KROME SCREW CORP., HARTFORD 10, CONN.

Sold only through authorized Holo-Krome distributors.

limit switch is said to have successfully completed severe kerosene and underwater tests.

Seven models and 19 contact arrangements are now available with the new watertight plastic covers. R. B. Denison Mfg. Co., 102 St. Clair Ave., N. W., Cleveland 13, Ohio.

For more information—
Circle 120, inside back cover



Small Ellipses Templates

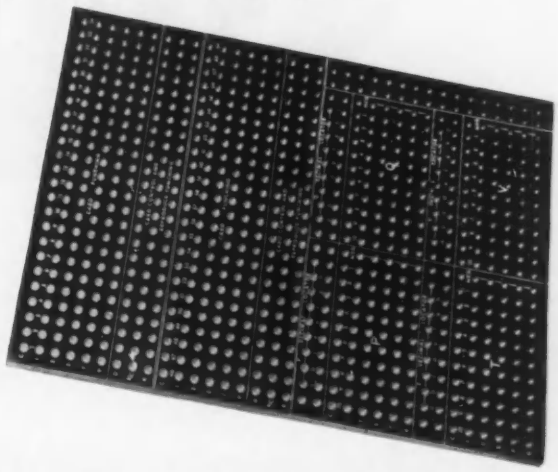
Template has 100 ellipses, in 10 projections from 15 to 60 deg, in 10 sizes from $\frac{3}{32}$ to $\frac{3}{16}$ in. Made of 0.020-in. amber colored mathematical quality plastic. Size is 6 x 4¾ in. Rapidesign, Inc., Box 592, Glendale, Calif.

For more information—
Circle 121, inside back cover

See the following pages for brief reviews of new publications offered for design engineers

DESIGNING WITH DUREZ

ENDS 5 COSTLY OPERATIONS . . .



ON UNIVAC* COMPUTER PANELS

You can get components to meet exacting dimensional requirements with less machining and finishing than you may have thought possible. Here's an example of how a switch to Durez phenolic—the engineering plastic—saved a major portion of a component's cost.

This is an interchangeable plug terminal panel in Remington Rand's Univac "120" digital computer. Temperature and humidity affect Durez so little that 816 molded-in holes plus 34 slots and precision-fitting edges in each 8" x 10" panel conform to close tolerances. Secondary drilling, milling, and grinding are eliminated, while brushing and varnish-dipping are unnecessary.

Durez is noted for its electrical properties, impact strength, and resistance to heat, moisture, and chemical action. It molds readily in complex forms of varying section, and metal inserts can be molded in. All these properties come in many combinations. Let them help to solve your problems.

A HANDY NEW BOOKLET of technical information will be sent on request.
Ask for "Facts on Phenolics."

DUREZ®
Phenolic Plastics that fit the job

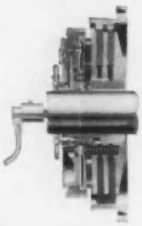
DUREZ PLASTICS DIVISION
HOOKER ELECTROCHEMICAL COMPANY
1505 Walck Road, North Tonawanda, N. Y.

HOOKER® CHEMICALS & PLASTICS

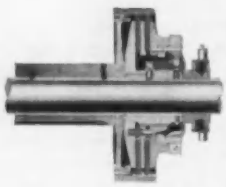
*Made by Remington Rand Univac® Division of Sperry Rand Corporation

Dependability First!

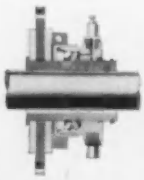
DODGE CLUTCHES



DODGE AIR-GRIP—quickest acting, most responsive air clutch available. May be "inched" or thrown into full engagement, as required. Built-in quick release valves, optional. Unique design and automatic internal ventilation insure cooler operation, longer life. Provision for mechanical engagement if air supply fails. Single and double plate types.



DODGE DIAMOND D—ruggedly built of highest grade materials, to resist wear and withstand shock loads. Smooth, trouble-free operation. Relatively light force on shifter is converted into a heavy power transmitting pressure between friction surfaces. One point shifting mechanism. Compact, completely enclosed for safety and protection from dust. Precision-built in sizes rated from 20 to 330 hp at 100 rpm.



DODGE ROLLING GRIP—simple and compact in design—no toggles. All working parts easily accessible. Power transmitting pressure on friction disc is developed by circle of hardened steel balls forced into wedge-shaped groove by the sliding cam. Flexible, easily controlled, extremely rugged. Single and double friction plate designs, sizes .38 to 21.2 hp at 100 rpm.

Write us now for Bulletins on Dodge Clutches.

DODGE
of Mishawaka, Ind.

Call the Transmissioneer, your local Dodge Distributor. Factory trained by Dodge, he can give you valuable assistance on new, cost-saving methods. Look for his name under "Power Transmission Machinery" in your classified telephone directory, or write us.

DODGE MANUFACTURING CORPORATION, 1200 UNION ST., MISHAWAKA, INDIANA

CATALOGS and BULLETINS

To obtain copies of literaure described below, circle corresponding number on postcard inside back cover. For those catalogs and bulletins available only when requested on company letterhead, see page 380.

Synchros, Servos, Resolvers–Bulletin 376, 4 pp, gives characteristics of over 138 units. Norden-Ketay Corp., 555 Broadway, New York 12, N. Y.
Circle 122, inside back cover

Roller Bearings–Bulletin H-54A, 55 pp, describes cam follower, integral end shoulder and guided roller bearings. McGill Mfg. Co., Valparaiso, Ind.
Circle 123, inside back cover

Locknuts–Booklet, 24 pp, covers 14 topics concerning manufacture and proper installation of locknuts. Guide chart for calculating wrench torques, as well as all of the variables that must be considered in relation to bolt tightness and wrench torques, are included. National Machine Products Co., 44225 Utica Road, Utica, Mich.
Circle 124, inside back cover

Fasteners for Spotwelding–Bulletin 561, 4 pp, describes pins, screws, nuts designed to be spotwelded into various end products. Ohio Nut & Bolt Co., 33 First Ave., Berea, Ohio.
Circle 125, inside back cover

Molded Friction Elements–Bulletin 550, 16 pp, has section on engineering design data so product designers can determine shapes and sizes in which these products can best be produced. Chamfers and radii are illustrated. Machinability and dies are also covered in detail. Raybestos-Manhattan, Inc., 6010 Northwest Highway, Chicago 31, Ill.
Circle 126, inside back cover

Fluorocarbon Rubber–Booklet, 16 pp, gives gum characteristics and properties of the resulting vulcanizates, including physicals, thermal stability, water absorption, gas permeability, low temperature behavior, electrical values, and chemical resistance. M. W. Kellogg Co., P. O. Box 469, Jersey City 3, N. J.
Circle 127, inside back cover

Solenoids–Catalog describes explosionproof, oil-immersed solenoids, solenoid-operated brakes, solenoid-based (reciprocating action) motors. Trombetta Solenoid Co., 329 N. Milwaukee St., Milwaukee 2, Wis.
Circle 128, inside back cover

Heaters and Heating Devices–Bulletin GEC-1005G, 60 pp, contains application index, calculating data, specifications, operating information and list prices of standard heaters and heating devices. General Electric Co., Schenectady 5, N. Y.
Circle 129, inside back cover

Compressed Air–Booklet, 20 pp, discusses moisture problems in air lines and what can be done about them. Accompanying brochure describes method for removing moisture from air, hydrogen, nitrogen and natural gas lines. Van Products Co., 5780 Old Ridge Road, Erie 7, Pa.
Circle 130, inside back cover

Stainless Steel Wire–Bulletin, 6 pp, includes analyses, tensile strengths, physical properties and gages of twelve types of stainless wire. Webb Wire Div., Carpenter Steel Co., New Brunswick, N. J.
Circle 131, inside back cover

Air or Oil Cylinders–Bulletin, 6 pp, gives mounting dimensions and specifications on eight standard styles offered in 1 to 3 in. bores, and seven styles in 4 to 8 in. bores. Recommended for air to 200 psi, oil pressure to 750 psi. Tomkins Johnson Co., Jackson, Mich.
Circle 132, inside back cover

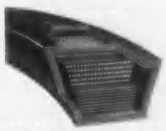
Ball Bearings–Bulletin S-61, 4 pp, has data covering types of ball bearings, sizes, installation and suggested applications. Freeway Washer & Stamping Co., P. O. Box 1756, Cleveland 5, Ohio.
Circle 133, inside back cover

Electronic Terminals, Seals–Catalog describes multiple headers, terminals,
(Continued on page 358)

DODGE PRODUCTS you should know

TAPER-LOCK
ALL-STEEL
CONVEYOR PULLEYS

SC and SCM
BALL BEARING
PILLOW BLOCKS



SEALED-LIFE V-BELTS

DODGE BULLETINS YOU SHOULD HAVE

- TAPER-LOCK STEEL CONVEYOR PULLEYS. Construction details, sizes, dimensions. Bulletin D56.
- ROLLING BEARINGS. Load ratings, dimensions and other data on Dodge-Timken and SC and SCM Ball Bearings. Bulletin A638.
- SEALED-LIFE V-BELTS. Construction details and data on sizes, pitch lengths and outside lengths. Bulletin A-606.

Write for your copies.
DODGE MANUFACTURING CORPORATION
1200 Union Street • Mishawaka, Indiana

DODGE
of Mishawaka, Ind.

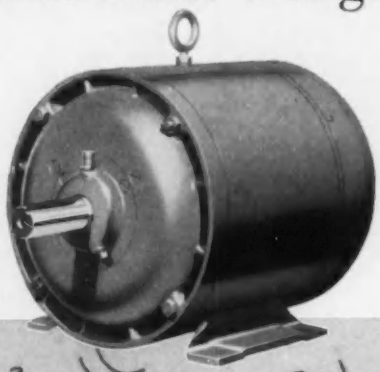
HOWELL MOTOR BRIEFS

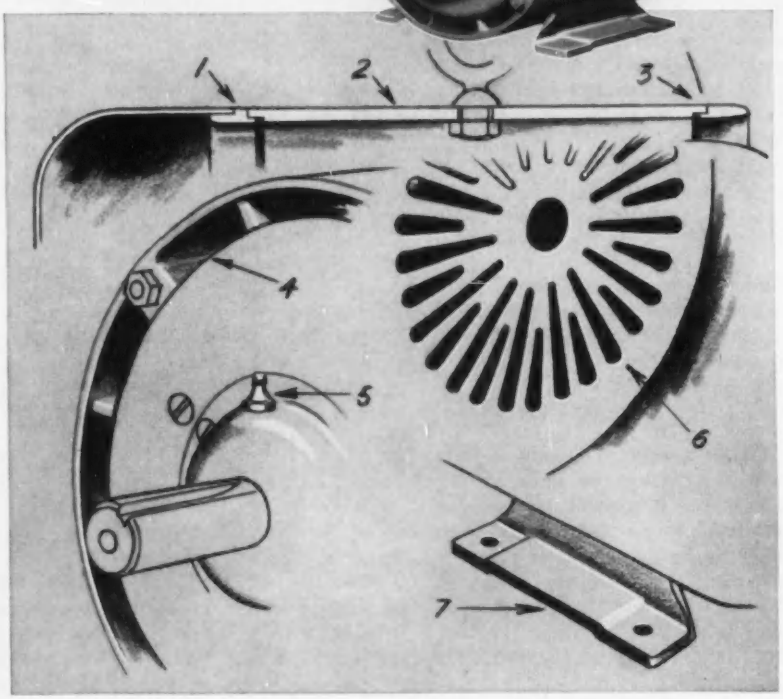
Quick facts for those who apply and specify electric motors

Eye Appeal: New Requirement in Motor Design

As the trend to automation accelerates and the number of individual drives per machine increases, electric motors become, more than ever, an important element in the overall appearance of many machines. In designing the Howell Series 100 motors in the new frame sizes, Howell engineers set up the list of design requirements shown below. For evidence of how they met them, see the totally enclosed fan cooled motor at right and the detail sketches below it.

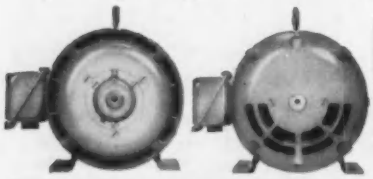
When you're specifying motors, why not specify for streamlined appearance — in addition to the top performance you need? It's a bonus value that costs no more and you'll be matching functional efficiency with sleek good looks.





HOWELL SERIES 100 TEFC EXTERIOR DESIGN REQUIREMENTS

1. Fan cover, end-plate and frame to join so as to produce flush exterior surface.
2. No fins, ribs or other protrusions, other than conduit box and feet, around entire diameter of frame.
3. Joint between frame and end-plate to present flush exterior surface.
4. Ventilation ports to carry out contemporary streamlining, offer minimum obstruction to passage of air, and meet or better NEMA specifications for safety.
5. Grease fittings, top-ball type, to be located for (1) easy accessibility (2) maximum protection against damage.
6. Fan guard openings to incorporate distinctive design and to meet or exceed NEMA specifications for safety.
7. Mounting feet to eliminate excess bulk and weight, utilize steel's strength to best advantage. Contours to present good appearance.



Open-type motors in the Howell Series 100 line match their TEFC counterparts not only in streamlined good looks, (see above right), but in diameter and mounting dimensions. Space allocations are simplified.

Series 100 enclosures: totally enclosed fan cooled, open drip-proof, splash-proof and weather protected, and totally enclosed non-ventilated.

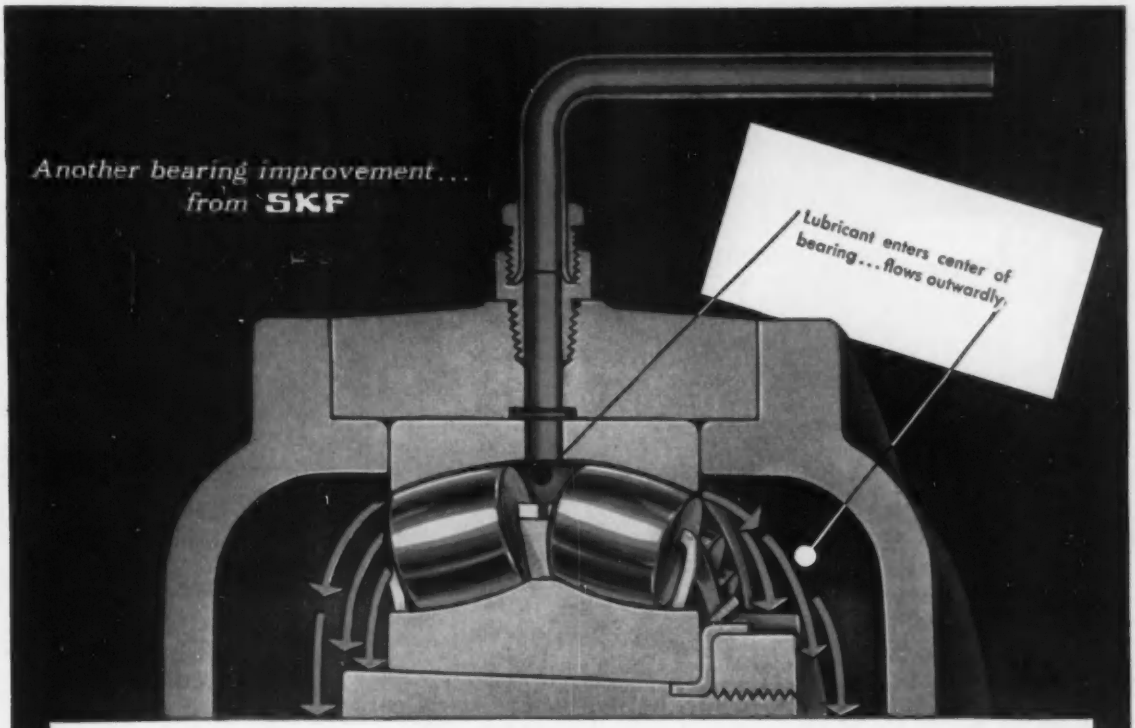
Get complete details on these outstanding new motors today . . . write for Bulletin N-100-R

HOWELL Red Band MOTORS

HOWELL MOTORS

HOWELL ELECTRIC MOTORS COMPANY, HOWELL, MICHIGAN

PRECISION-BUILT MOTORS FOR INDUSTRY SINCE 1915



NOW AT NO EXTRA CHARGE—

SKF's improved method of lubricating large spherical roller bearings

To make the lubricant effective it should be located where needed—in the bearing. Also, new lubricant, when added, should enter where it does the most good—in the bearing.

For these reasons, all future production of SKF double row spherical roller bearings above 240 mm O.D. (9.4488") will be made with three equally spaced drilled holes in the center of the outer ring without any extra charge to our customers. *This permits the lubricant to enter the center of the bearing.*

With the lubricant (either grease or oil) being introduced into the center of the bearing, all working surfaces are quickly and completely covered. In addition, the outward flow flushes out the old lubricant, and with it, any abrasive dust, dirt, moisture or other impurities.

And where circulating oil lubrication is required, there is a continuous flushing and cooling of the bearing.

This is another example of how SKF helps you to obtain longer bearing life.

7200

Consult your SKF District Office today for complete information so that you can be the first to incorporate into your products this improved method of lubricating large spherical roller bearings.

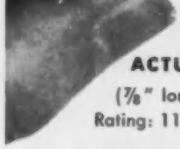
SKF®

BALL AND ROLLER BEARINGS

SKF INDUSTRIES, INC., PHILADELPHIA 32, PA.

—*manufacturers of* SKF *and* HESS-BRIGHT® *bearings.*

there's an amazing
CONCENTRATION OF HEAT
in this tiny cartridge unit!
the new WATLOW
FIREROD
cartridge heaters



ACTUAL SIZE
(⅞" long, ⅜" dia.)
Rating: 115 V. —125 W.

A new design advantage for you. As *much heat* in 1/5th the space. Standard Units from 1¼" to 12" long, ⅜" and ½" dia.

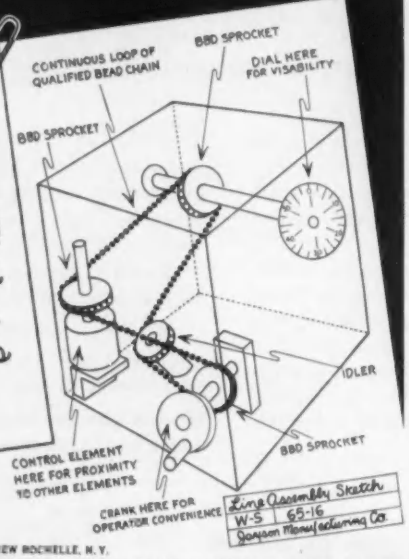
Example of Application
Used to heat metal die to 900°F. forming titanium in the Aircraft Industry.

WRITE . . . for Illustrated Bulletin.

WATLOW
SINCE 1922—DESIGNERS AND MANUFACTURERS OF ELECTRIC HEATING UNITS
ELECTRIC MFG. CO.
1392 FERGUSON AVE.
SAINT LOUIS 14, MO.

INTER-OFFICE MEMO
FROM: BILL KEISLER—CHIEF ENG.
TO: Stanley Bier

Stan - This seems like an excellent solution - 4 sprockets and a loop of chain replace 6 or 8 gears, bearings and supports! Let's use them. They're called BEAD BELT DRIVES. Please write today for samples or more info. Bill



BEAD BELT DRIVES
VOLAND & SONS, INC., 32 RELYEA PLACE, DEPT 101, NEW ROCHELLE, N.Y.

MAIL COUPON TODAY

Voland & Sons, Inc. Dept. 101
32 Relyea Place, New Rochelle, N. Y

Gentlemen:
Please rush me.....sample kits of Bead Belt Sprockets and chain at $5.00 per kit. Each kit consists of 12 assorted brass and die-cast sprockets, chain, and connectors with instructions for assembling endless belts.

☐ Bill my firm ☐ Check enclosed
☐ Please send complete information

Name.....
Firm.....
Address.....
City.....Zone.....State.....

seals, closures. Electrical Industries, 44 Summer Ave., Newark 4, N. J.
Circle 134, inside back cover

Magnesium Alloy Nomenclature—Pamphlet, 12 pp, has standard alloy nomenclature and temper designations which have been adopted by the ASTM and is being officially recognized and recommended by Magnesium Assn., 122 E. 42 St., New York 17, N. Y.
Circle 135, inside back cover

Chemical Metal Finishing—Booklet, 12 pp, describes aluminum anodizing and alodizing, surface conditioning, and various other types of conversion coatings obtainable on aluminum, magnesium and steel. J. W. Rex Co., 843 W. 3 St., Lansdale, Pa.
Circle 136, inside back cover

Variable Speed Transmissions—Catalog 65, 24 pp, describes construction, accessories and controls, both manual and automatic. Engineering section gives power transmission characteristics, ratings and dimensions. Lewellen Mfg. Co., Columbus, Ind.
Circle 137, inside back cover

Nylon Molding Powder—Folder, 6 pp, includes test data. National Polymer Products, Inc., 125 N. 4 St., Reading, Pa.
Circle 138, inside back cover

Pilot Light Assemblies—Catalog 750, 11 pp, describes indicating lights for control panels and equipment. E. F. Johnson Co., Waseca, Minn.
Circle 139, inside back cover

Indexing Machinery—Catalog 106, 24 pp, discusses selection, designing of indexing units into equipment, calculation of applications requirements, standard dimensions. Ferguson Machine & Tool Co., Inc., P. O. Box 5841, St. Louis 21, Mo.
Circle 140, inside back cover

Hydraulic Controls—Bulletin 102, 4 pp, describes control centers for aircraft, industrial and mobile hydraulic systems. Electrol Inc., Kingston, N. Y.
Circle 141, inside back cover

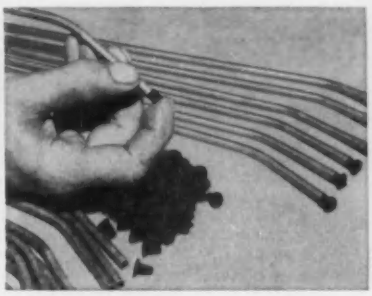
Ball Screws and Splines—Bulletin, 4 pp, provides table of capacities, dimensions, ball nut data, torque rat-
(Continued on page 362)

Tough, Flexible CaPlugs Are Used in Countless Ways to Protect Products in Process, Storage and Transit

Quick to put on... kind to threads... add sales sparkle

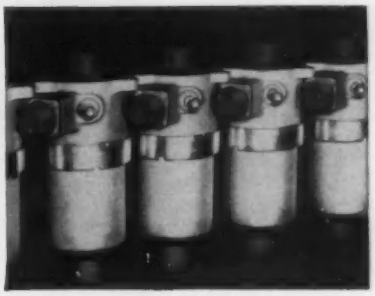
JUST PUSH THEM ON . . . OR PUSH THEM IN

Tapered CaPlugs can be used as caps or plugs, inside or outside of threaded or plain fittings. Costing less to buy, these versatile closures cost less to apply. Time studies show that Tapered CaPlugs save up to 500% in labor costs.



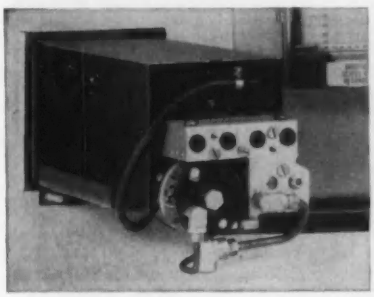
USED BY THOUSANDS OF INDUSTRIES

Here, CaPlugs are applied by Caterpillar Tractor Co., ". . . to protect and keep clean the tubing used in fuel injection equipment for diesel engines." Made of Polyethylene, CaPlugs will not collapse, chip, break or shred under most severe of conditions.



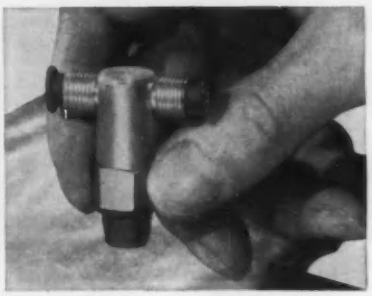
FIT MULTITUDES OF PRODUCTS

CaPlugs protect electrical connector fittings and armature shaft extensions of these electric motor assemblies. Here's sure, safe protection that's adaptable to all types of products and parts. (Photograph courtesy Pesco Products Division, Borg-Warner Corporation)



EASY TO REMOVE, TOO!

Installed on these Bristol air control instruments, CaPlugs prevent dirt or foreign matter from getting into the system before installation. Says The Bristol Company, "They are sturdy enough so that they are not accidentally dislodged, but are still easily removable."



INDICATES CARE IN MANUFACTURE

On this Alemite Accumatic Valve, colorful red CaPlugs add zestful eye appeal. Says Stewart-Warner Corp., "CaPlugs help impress the customer with the steps that have been taken to protect the equipment and convince him of the continuing need for protecting lubricants against contamination."

YOU NAME IT

There's a CaPlug to fit nearly every closure need. With six standardized designs (both threaded and non-threaded) and over 275 stock sizes available, "off-the-shelf" deliveries can be made to meet your immediate requirements without delay. Write for free samples and prices.

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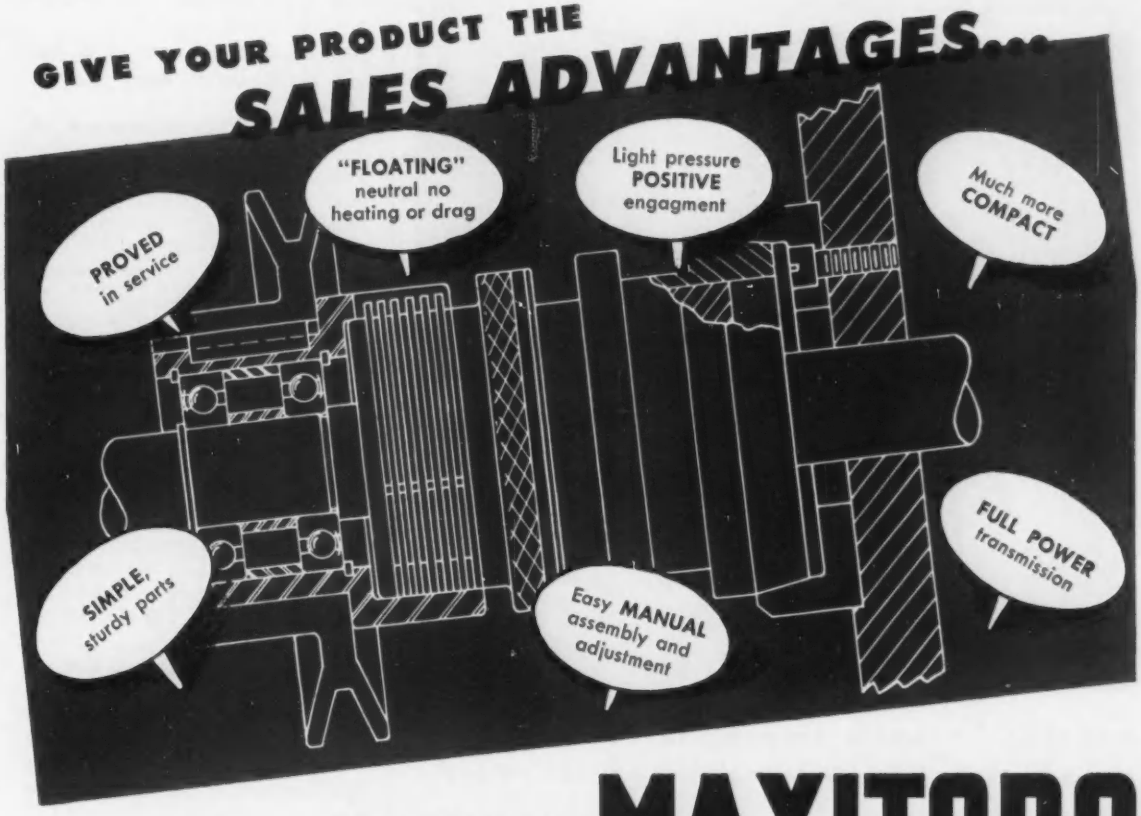
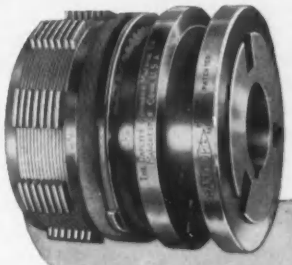
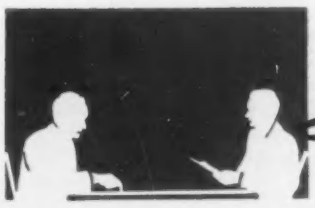


...OF A PROVEN MAXITORQ floating disc CLUTCH



The above line drawing illustrates a single MAXITORQ Clutch arranged for single V-belt drive with a special sliding beveled shifter sleeve acting as a light brake.

Yes, there are many types of MAXITORQ . . . single, double, overload release . . . to meet every installation need. Get our comprehensive technical data . . . let our engineering department help you work out special drive problems. Write or phone: Dept. PE-5, The Carlyle Johnson Machine Company, Manchester, Conn.



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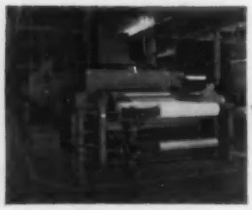
Fabricon Plastic Impregnated Materials help MAKE GOOD PRODUCTS BETTER!

Time was when fly rods . . . like some structural members for airplanes . . . could only be made of bamboo. But not so today. Now, Fabricon plastic impregnated glass cloth is being used in many secondary airframe assemblies for both commercial and military aircraft. It's been adopted, too, by manufacturers of fishing equipment as a practical successor to costly bamboo. They say it's every bit as good . . . and much better in many respects. For glass cloth rods are lighter, stronger, easier to use. They last much longer . . . require less care and fewer repairs than the best bamboo rod ever made. What's more, they've helped "catch" a whole new school of avid anglers by bringing the price of a good fly rod well within the reach of millions.

Specially treated glass cloth . . . for fishin' poles and flyin' machines, plus a host of other diversified things . . . is only one of many plastic impregnated and coated materials now being produced by Fabricon to help make good products better. Others include: special grades of paper for industrial and decorative laminates; asbestos for radiant heating panels; cotton duck for gears and other mechanical parts; filter papers and cloth for automotive, industrial and medical applications; plus a number of other exclusive impregnated materials developed by Fabricon to meet the specific requirements of many different products . . . *perhaps yours included!*

Complete laboratory facilities for developing new products and processes.



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ings. Beaver Precision Products, Inc., 651 N. Rochester Road, Clawson, Mich.

Circle 142, inside back cover

Titanium—Books (5) describe development programs on titanium and titanium alloys, concerning production and design of components made of these materials. Purpose of publications is to broadcast all possible information as a means of eliciting useful information and assistance. Air Material Commercial, MCPBIS-2, Wright-Patterson Air Force Base, Ohio

Circle 143, inside back cover

Indexing Turntables—Catalog 88-56, 12 pp, describes about 150 various types of indexing turntables, rotating turntables and tables that can be set to practically any angle. Eisler Engineering Co., Inc., 750 So. 13 St., Newark 3, N. J.

Circle 144, inside back cover

Wire-Wound Resistors—Bulletin C-1A, 12 pp, has data on construction, features, types, ratings, terminations and leads, coating, insulation, winding. International Resistance Co., 401 N. Broad St., Philadelphia 8, Pa.

Circle 145, inside back cover

Hydraulic Valves—Bulletin A-5209, 8 pp, describes special and standard hydraulic valves for airborne applications. Vickers Inc., Detroit 32, Mich.

Circle 146, inide back cover

Noise Control—Catalog SZ-55, 4 pp, describes wire-reinforced rubber pipe for eliminating noise and vibration from fluid lines. T. R. Finn & Co., Inc., 200 Central Ave., Hawthorne, N. J.

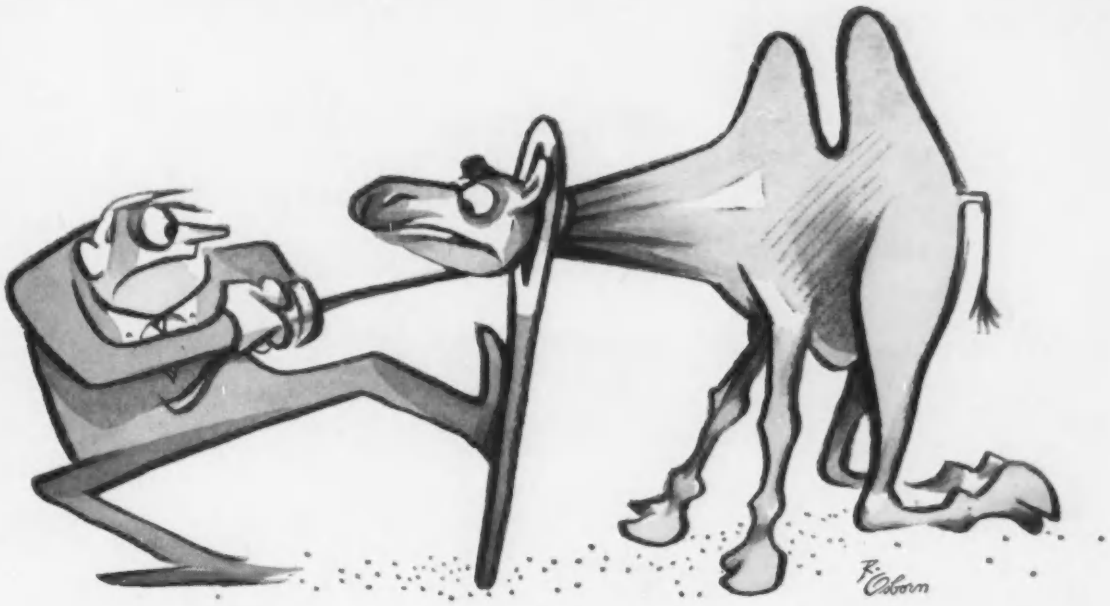
Circle 147, inside back cover

Colloidal Dispersions—First issue of house organ describes applications of colloidal graphite and molybdenum disulfide. Acheson Colloids Co., Port Huron, Mich.

Circle 148, inside back cover

Rubber-to-Metal Bonds—Brochure, 8 pp. describes the bonding of rubber (natural and synthetic) and silicones to metals. Photos show industrial applications. Acushnet Process Co., 768 Belleville Ave., New Bedford, Mass.

Circle 149, inside back cover



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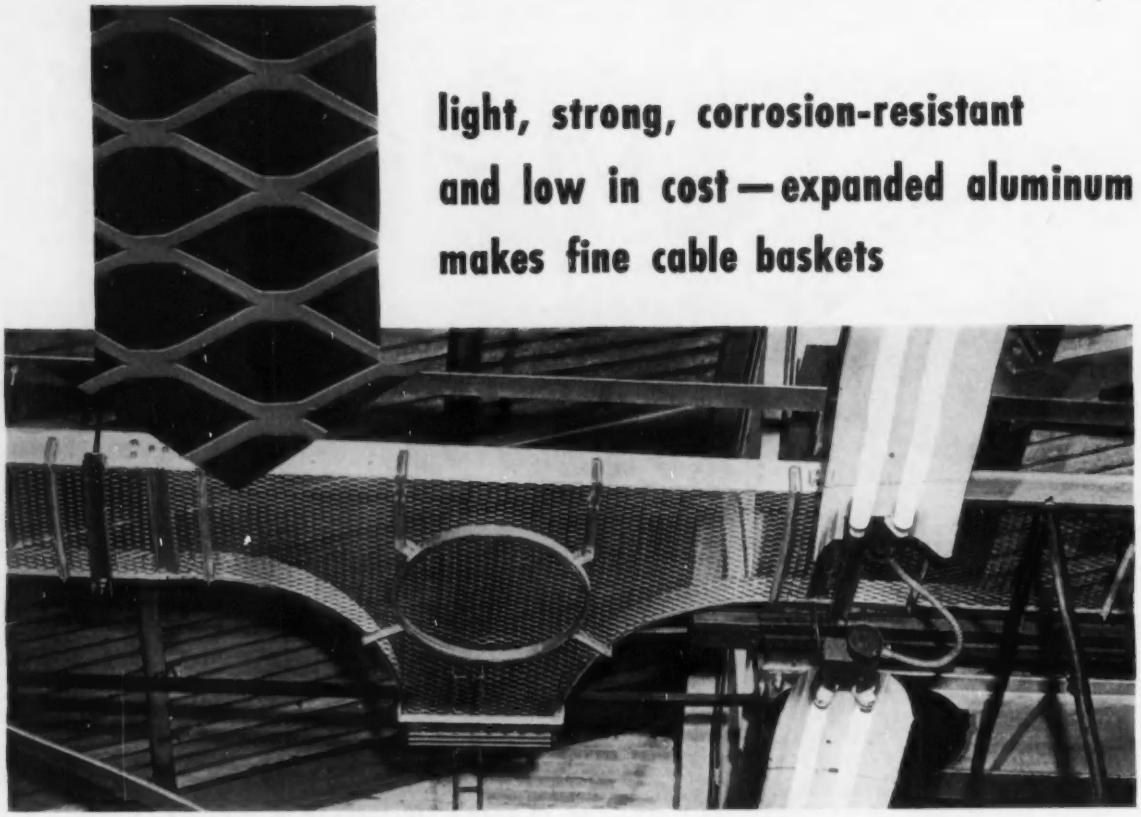

Add up the advantages of Penmetal expanded aluminum and you can see why Husky Products, Inc. uses it for their line of cable baskets.

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Penmetal

PM-105

The Baskets in the photos carry electric cables in power plants, industrial installations, etc. They were made from Penmetal ¾" flattened expanded aluminum—by Husky Products, Inc., Cincinnati, Ohio

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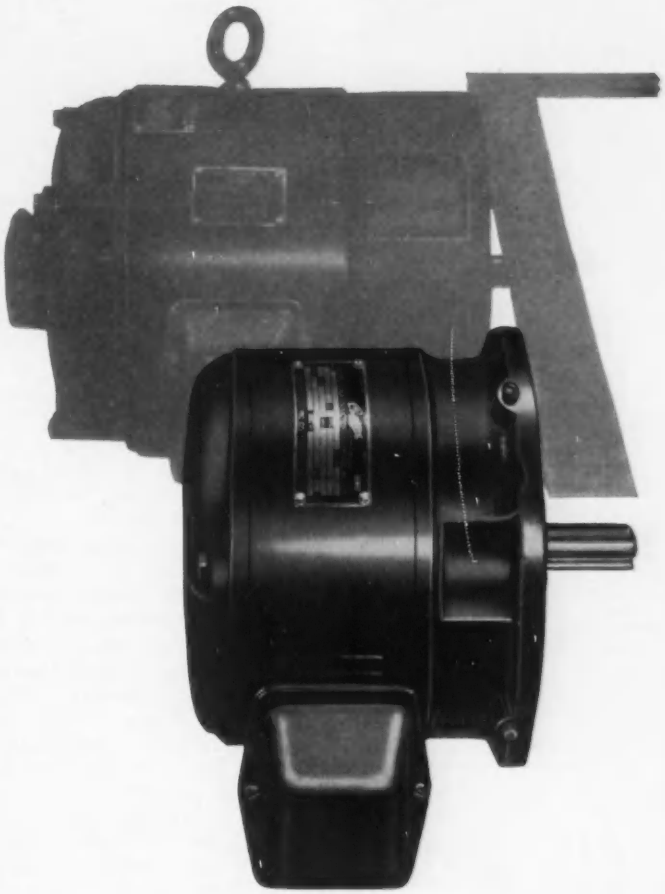
This new line of shorter, round-frame, end-mounted motors by Century can give you greater freedom in design and engineering. They meet modern demands for compactness and weight-saving ... with even better performance.

No special mountings are required! These shorter Century motors have full-size NEMA "D" flanges. They are interchangeable with all other popular makes of standard end-mounted motors. The shorter motors are available in sizes from 1 to 15 H.P... in open or totally enclosed fan-cooled frames ... for vertical or horizontal applications.

For full data, call your nearest Century Sales Office.



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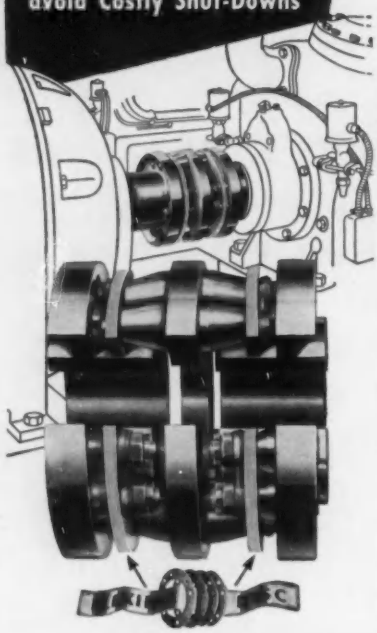
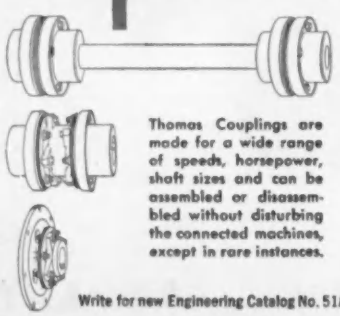
Specify THOMAS ALL METAL FLEXIBLE COUPLINGS for Power Transmission to avoid Costly Shut-Downs



Patented Flexible Disc Rings of special steel transmit the power and provide for parallel and angular misalignment as well as free end float.

DISTINCTIVE ADVANTAGES

FACTS	EXPLANATION
NO MAINTENANCE	Requires No Attention. Visual Inspection While Operating.
NO LUBRICATION	No Wearing Parts. Freedom from Shut-downs.
NO BACKLASH	No Loose Parts. All Parts Solidly Bolted.
CAN NOT "CREATE" THRUST	Free End Float under Load and Misalignment. No Rubbing Action to cause Axial Movement.
PERMANENT TORSIONAL CHARACTERISTICS	Drives Like a Solid Coupling. Elastic Constant Does Not Change. Original Balance is Maintained.



Thomas Couplings are made for a wide range of speeds, horsepower, shaft sizes and can be assembled or disassembled without disturbing the connected machines, except in rare instances.

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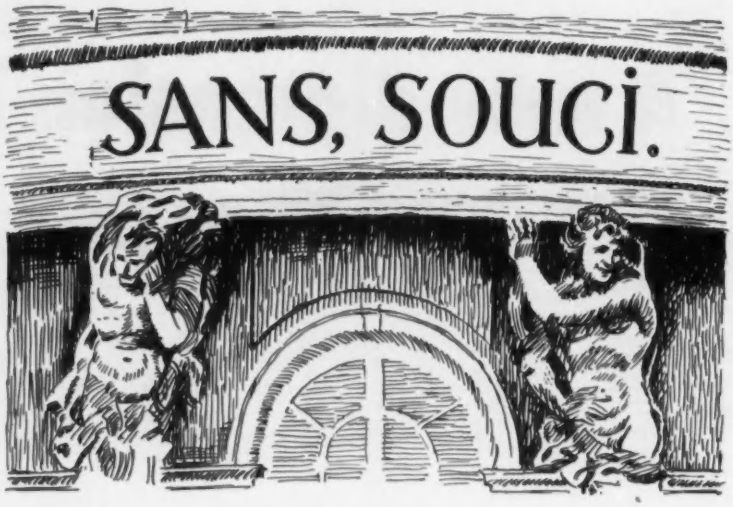
THOMAS FLEXIBLE COUPLING CO.
WARREN, PENNSYLVANIA, U.S.A.



Ad Libbing by the Editor

The moving picture, "The Court-Martial of Billy Mitchell," should give every engineer and inventor much food for thought. Because Colonel or Brigadier-General Mitchell was insubordinate and held the War Department and the Navy up to ridicule, one cannot argue with the verdict of guilty. But there are other aspects. Unfortunately, when the human mind focuses its thinking on a little black spot it becomes entirely oblivious to the broad expanse of pure white paper that might surround the ink blot. The War Department and Navy thinking was not broad enough to give serious thought to Billy Mitchell's convictions.

The tragedy of the verdict against Billy Mitchell does not lie in the fact that he was punished, and fittingly so according to the practices and precepts of the military. The tragedy was that the military brass had obviously become so incensed over Billy Mitchell's bold accusations that the minds of the individuals concerned did not even bother to give thought as to whether or not Billy Mitchell might have been at least partly right. Indeed, ten years later at least some Navy brass was boldly declaring that an airplane could not even damage a battleship.

In the late thirties I was having lunch with an ex Navy officer. In the course of our conversation he was asked, "In view of the sinking of the Spanish naval vessel by an airplane, does the Navy still claim that an airplane cannot damage a battleship?"

His answer was vehement, extremely so. "That was just by luck that the bomb went down the funnel. Couldn't happen again in a million times. As to Billy Mitchell's demonstration in which he bombed and sank those battleships, don't forget that the ships were undefended. Even at that, he had to make a second run to sink them."

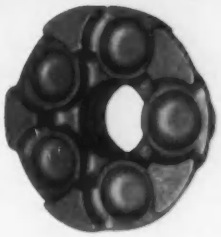
In the light of that statement, we have to admit this disheartening fact. This ex Navy officer was presumably reflecting opinions still prevailing in Navy circles more than 10 years after Billy Mitchell's trial and in the face of two dramatic demonstrations of air power.

Two principles were demonstrated in the Billy Mitchell case, and they are applicable in all fields of human relations. The first principle is an extremely difficult one for many people to accept. It is simply that **ignorance should never be permitted to sit in judgment of knowledge.** Yet the breach of that simple axiom is extremely prevalent. Indeed, many people refuse to accept that principle solely because it is so often broken.

A sales manager derided the top engineers of his company when they stated that an alloy steel press column will, for a given tension load and cross sectional area, stretch almost exactly the same amount as would a carbon steel column, the unit stress being below the yield point. The sales manager was not an engineer but he was an extremely eloquent, though irresponsible, talker. Many in his audience, other than those who were

(Continued on page 368)

Radiator shell, a deep-drawn stamping made of 16-ga. steel, in two sections, approximately 26 inches wide, 28 inches high, 10 inches deep.



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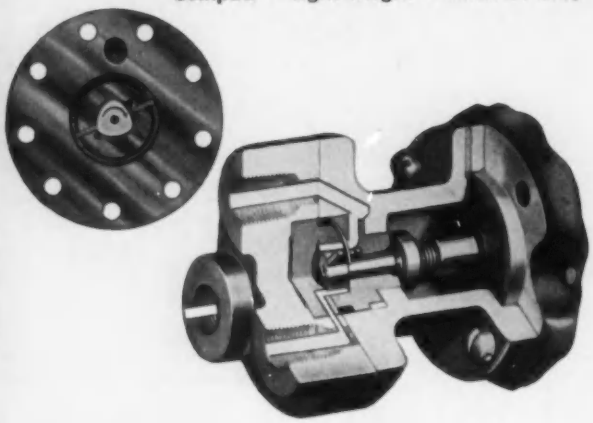
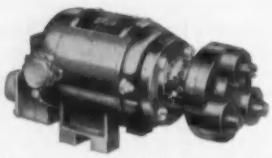
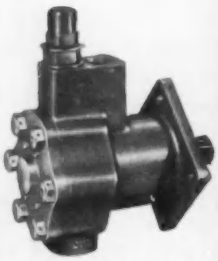


IT'S SO SIMPLE!

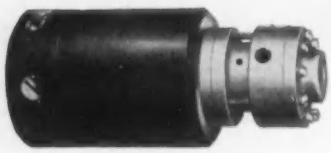
The rotation of the rotor draws the fluid in through two passages, filling the cavities formed by the three lobes of the rotor. This fluid is sealed within these small cavities until it is forced through the two outlet holes by the floating blades. The flow may be kept uniformly divided through two outlet ports, or may be combined internally for passage through a single port.



STYLE A—Single inlet double outlet type aircraft pump



STYLE F—Engine driven fuel pump



STYLE C—Industrial pump

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THE WELDON TOOL COMPANY

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design engineers, believed the sales manager. Some of the officials of that company still believe the sales manager was right and the chief engineer wrong.

When a man who does not possess an authoritative knowledge of a subject emphatically makes a statement concerning that subject, the statement should be treated as an opinion of questionable merit and not as a fact. Unfortunately, **when ignorance speaks to ignorance there can be no differentiation between opinion and fact.** Ignorance usually, or at least too often, accepts all as fact. The nation's most successful business leaders are those who seek and accept advice only from those who are authorities on the subject.

The Billy Mitchell fiasco, as distinct from the trial, demonstrated a second great principle. Regardless of race, creed, color, or intelligence, it is extremely common for people to lose decency, intelligence, justice, courage, and even the ability to think, when they come face to face with a situation wherein they would "lose face" if they were to do what they ought to do.

Billy Mitchell was guilty of defying his superiors, holding the War Department up to ridicule and other things of the same nature. He was convicted and suffered the penalty. But did that action alter the accomplished fact that bombs had sunk battleships, that the War Department had become stuffy, that the Navy Department was too cocky, and that all of them put together refused to even give a thought to Billy Mitchell's ideas? Did they refuse to do so because they might have then been forced into a position wherein they would be compelled to admit Billy Mitchell was right? Probably so, subconsciously at least. But whether or not, most humans are strongly afflicted with the human ailment called "face saving." This is something that is commonly looked upon as applying only to Orientials. Actually, it applies to all people, the only difference being the methods used to accomplish the same end result.

It is not uncommon to find men who take the stand that can be described as, "The idea is no good. If it were I would have thought of it first. And we have been operating for

(Continued on page 371)

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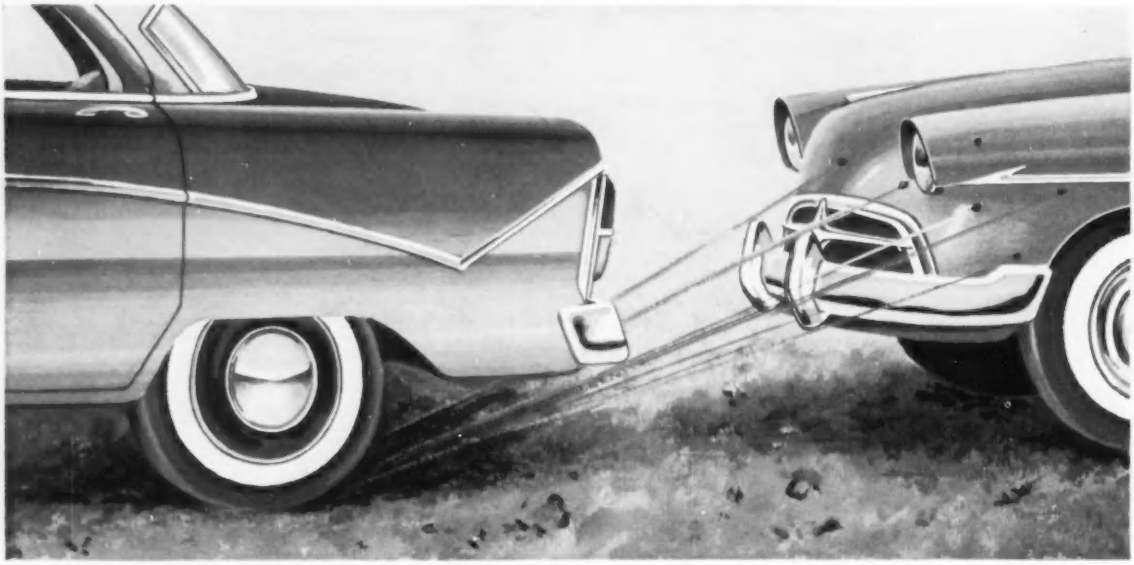
NOW—Startling impact and corrosion resistance under organic finishes...



with this NEW zinc-manganese phosphate coating—

PENNSALT FOSBOND 64!

Give rough-used painted metal surfaces the utmost protection from impact and corrosion—give them new FOSBOND® 64 zinc-manganese phosphate protection! Glossy organic finishes on steel surfaces such as auto bodies, appliances, and furniture stand up far longer under sharp, paint-chipping impacts when they've been locked on with Fosbond 64. Steel surfaces treated with Fosbond 64 resist corrosion from severe weathering far longer than steel treated with other phosphate coatings.

The outstanding protection offered by Fosbond 64 is the result of completely new thinking in phosphate coating. Fosbond 64 offers you a *new high* in reliability.

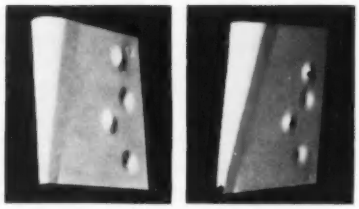
GET THE WHOLE STORY. If your product must withstand severe impact *and* severe corrosion, learn how Fosbond 64 protects against *both!* Call your Pennsalt man, or write Metal Processing Department 301, Pennsylvania Salt Manufacturing Company. East: Three Penn Center Plaza, Philadelphia 2, Pa.; West: Woolsey Bldg., 2168 Shattuck Ave., Berkeley 4, Calif. In Canada: Pennsalt Chemicals of Canada, Hamilton, Ontario.

Pennsalt Chemicals

Metal Cleaners • Phosphate Coatings • Cold-Working Lubricants

CHIP-RESISTANCE. Test panels pre-coated with Fosbond 64 take twice as many inch-pounds of impact (on standard DuPont Chip Tester) as finish applied over conventional zinc-phosphate coating.

SALT-SPRAY TEST. After 300-hour exposure, Fosbond 64 (left) allows no creep of corrosion under paint, while conventional zinc-phosphate coating (right) shows $\frac{1}{16}$" undermining of paint film.



IMPACT TEST. Paint applied over Fosbond 64 (left) doesn't fracture on direct and reverse impact and bending over conical mandrel, while paint over normal zinc-phosphate coating (right) fractures from same treatment.

A BETTER START FOR YOUR FINISH

many years without this proposed innovation, so we can continue without it. I will never admit to that upstart that I should have done this long ago, so I'll give him the brush off. And if he gets too persistent, I'll fire him."

Because the value of an engineer is built on the progress he puts into his product designs, he is forever, if he is good, proposing new ideas, new designs and new products. He is also often on the defensive trying to prevent his management from launching into an unsound design venture.

Because he cannot divorce himself from the facts, the engineer is usually at a disadvantage in contending against the nontechnical men of his organization. What should he do if his engineering design advice goes unheeded, if he finds himself overruled by other departments, if his company policy refuses to recognize scientific and technological developments? There is only one answer! Quit, and quit gracefully! Once the management has taken a firm stand and announced its decision not to deviate from that stand, its mind develops the obstinacy of the immovable object that tried to resist the irresistible force. Then everything shatters.

Billy Mitchell will always be honorded as a man of great vision, unbounded courage and of fiery determination. But his best was not enough. Even his sacrifice accomplished practically nothing.

When the engineer faces a "Billy Mitchell" situation the thing to do is either to go firmly on record or to quit gracefully.–G.F.N.

U. S. Government Engineers Get Pay Raise

For the third time within a year, the Civil Service Commission increased the starting pay for engineers and certain types of physical scientists in the lower grades. The reason for the increase was to put government pay levels on a more competitive basis with private industry, in an effort to recruit 8,700 more of the above two classifications into government work.

The new starting pay will be $4480 annually instead of $4345 in Grade 5, and $5335 instead of $4930 in Grade 7. Estimates place the cost at $4,424,000 a year.

Production costs "Automatically" reduced with Milford Rivets and Rivet-Setting Machines

Here's a team that cuts production costs and makes the job simpler—Milford Rivets made to high quality standards to assure a better assembled product . . . Milford Rivet-Setting Machines that can be readily adapted to your production needs.

To reduce delivery time and production costs, to improve product appearance, to assemble your product on automatic rivet-setting machines—get in touch with Milford right away!

THE MILFORD RIVET

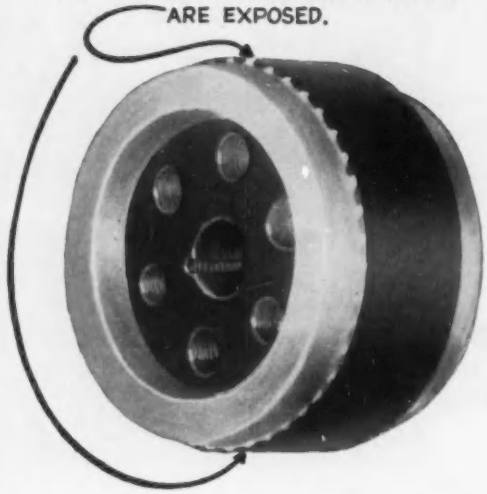
MILFORD RIVET & MACHINE CO.

MILFORD, CONNECTICUT • HATBORO, PENNSYLVANIA
ELYRIA, OHIO • AURORA, ILLINOIS • NORWALK, CALIF.

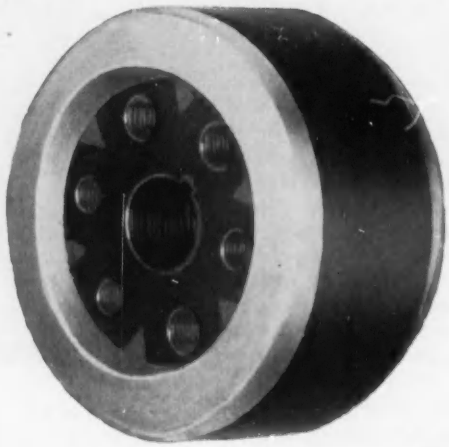
Emerson-Electric engineering highlights

NEW . . . Improved die-cast aluminum rotor

OLD-STYLE ROTOR DESIGN, SHOWING HOW PART OF THE ALUMINUM CONDUCTOR BARS ARE EXPOSED.



NEW, IMPROVED EMERSON-ELECTRIC ROTOR END-RING DESIGN, WHICH ELIMINATES NEED FOR FINISH TURNING.



New end-ring design assures more years of trouble-free service, provides superior strength, durability and operating efficiency

The introduction of the improved Emerson-Electric rotor-end-ring design obsoleted ordinary rotor construction. It was unreliable and often resulted in motor trouble, also possible damage to associated equipment.

This was due to the fact that in chamfering, or finish-turning the rotor periphery, steel and aluminum flakes were often left on the cut. In a power motor, these chips or flakes could lodge between the current-carrying wires of the stator winding and cause a short. In a hermetic motor, if the chips got past the winding, they would certainly become lodged somewhere in the refrigeration system and could cause a compressor to fail.

Now, Emerson-Electric rotor-end-ring design has eliminated these damaging possibilities, by eliminating the need for chamfering.

Basically, with this new design, no active material is removed from the rotor—therefore, no chips can be left to cause damage or failure of the unit!

There are added advantages: Increased contact area between the end rings and the aluminum conductors provides a better path for current flow. Spreading of laminations is avoided, because of the stronger support of the end laminations.

This is but one of many Emerson-Electric "highlight" features that appeal to designers and manufacturers of motor-driven equipment. It is another reason why Emerson-Electric has been recognized as a leader in the design of motors for more than 60 years.

Call on Emerson-Electric motor-drive specialists

Consult Emerson-Electric specialists on any phase of your motor-drive applications. Their wide experience is valuable, whether you're designing or re-designing for performance and sales. Write for Bulletin No. M-33. THE EMERSON ELECTRIC MFG. CO., ST. LOUIS 21, MISSOURI.

Emerson-Electric of St. Louis • Since 1890

BRANCHES: NEW YORK 7, N. Y., 11 Park Place • CHICAGO 23, ILL., 1623 S. Pulaski Road • SYRACUSE, N. Y., 209 Oakley Drive
PHILADELPHIA (Secane), PA., 868 Quince Lane • DETROIT 7, MICH., 1375 E. Jefferson Ave. • CLEVELAND 16, OHIO, 1580 Rockland Ave.
LOS ANGELES 42, CALIF., 5415 York Blvd. • DAVENPORT, IOWA, 617 Brady Street • CINCINNATI 11, OHIO, 2917 Ratterman Ave.

Use WELDED STEEL for Greater Strength with Less Weight!

The 65-ton weldment above is the crown for a large press. This piece, and the parts and assemblies illustrated at the left, are typical of thousands of Steel-Weld Fabricated units produced and machined by Mahon for manufacturers of processing machinery, machine tools, and other types of heavy mechanical equipment. Are YOU making full use of welded steel components in your products? In the design of almost any type of heavy machinery there are pieces and sub-assemblies that can be produced more economically in welded steel—and with the additional advantages of less weight, greater rigidity and predictability. When you consider weldments, think of Mahon . . . because, you will find the Mahon organization a unique source of supply for welded steel in any form . . . a source with complete facilities for design engineering, fabricating, machining and assembling . . . a source where design skill and advanced fabricating techniques are supplemented by craftsmanship which assures you a finer appearing product embodying every advantage of Steel-Weld Fabrication. See Sweet's Product Design File for information, or, better still, have a Mahon sales-engineer call at your convenience.

THE R. C. MAHON COMPANY • Detroit 34, Michigan

Sales-Engineering Offices in Detroit, New York and Chicago

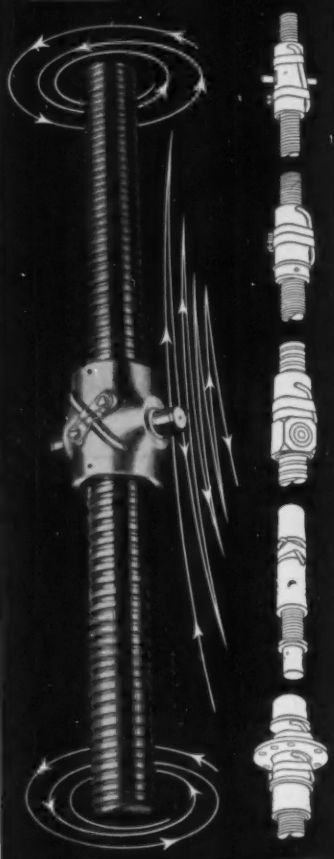
Engineers and Fabricators of Steel in Any Form for Any Purpose

MAHON

beaver

ball screws

Successor to the Acme screw drive and preferred in many applications to hydraulic and pneumatic systems. Guaranteed 90% efficiency in converting rotary twist to linear push (or vice versa). Employs a stream of precision balls and ground lead to eliminate drag and wear in delicate instruments to massive wind tunnel jacks. Any diameter or travel: indexing, inching, traversing. Literature, consulting engineering service available.



Fastest growing source for ball screws

Beaver Precision Products INC.

CLAWSON, MICH.

ABSTRACTS

Practice of Engineering By Corporations

Abstracted from "Professional Aspects of the Practice of Engineering," by Russell G. Warner, Chairman, ECPD Recognition Committee, and Chairman, EJC-ECPD Joint Committee on Practice of Engineering, *Mechanical Engineering*, Jan. 1956.

Frequently engineering problems are so complex that many engineers, with a diversity of knowledge and skill, are required to work closely together to arrive at an over-all solution.

It is logical then for groups of engineers to become associated together for consulting practice. Some engineers form partnerships and others prefer the corporate form of business. Should engineers have the freedom to follow their professional activities through the type of firm of their choosing?

Some feel that the corporate form of business seriously detracts from professional standing. Others fear that the corporate form may permit others, who are not engineers, to form policy, possibly to the extent of overruling the judgment of the engineers. Some propose to overcome this latter objection by specific requirements; such as, that all officers, or all the directors, or in the extreme that all the stockholders, be professional engineers. Although this latter view is held by several leaders of consulting-engineering corporations, there are many who feel that such restrictions are unnecessary and undesirable from the standpoint of economic service to the public.

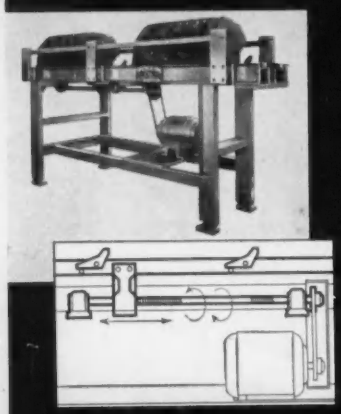
In general, manufactured goods are sold at a price to include the engineering. A large number of engineers combine their skills to design cars and other engineers develop the machines to produce them. Because it is the usual or common practice for the manufacturing corporation to hire professional engineers as its employees to design its products, most will agree that this practice is not objectionable.

It has been said that "the ethics of the engineer employed by a corporation are necessarily those of the corporation." There may have been cases where the ethics of the engineer have

(Continued on page 378)

The same principle used in raising landing gear

automatically shuttles engine blocks



Beaver Ball Screws were selected by Spurgeon Co., Van Dyke, Michigan, for this device which synchronizes transfer of engine blocks between production machines—WHY?

1. *Superior in performance and wear to Acme screws. Less power required.*
2. *Costs less to install and maintain than hydraulic cylinder. No oil leakage.*
3. *Costs less than air cylinder and costs less to maintain. Operates smoother. No air hookup required.*

Can your product be made more efficient with Beaver Ball Screws? Write for literature.

Beaver Precision Products INC.

CLAWSON, MICH.

The aircraft of tomorrow will fly hotter and higher. This means higher temperature requirements for aircraft cable preinsulated terminals. A-MP research has anticipated this need, and now releases STRATO-THERM—

the finest preinsulated terminal created for use at higher temperatures.

STRATO-THERM Terminals introduce new preinsulation which has been tested satisfactorily at temperatures from minus 65°F up to 400°F STRATO-THERM Terminals can be crimped at minus 15° and performance exceeds all requirements of MIL-T-7928A. They are applied with the new A-MP T-Head Tool, the same tool that also crimps the A-MP vinyl or nylon Preinsulated Diamond Grip Terminals and Connectors, universally used by the aircraft industry for many years.

STRATO-THERM®

the cool terminal for hot planes

Ask your A-MP sales engineer about STRATO-THERM Terminals and Connectors or write to the General Office.

STRATO-THERM Terminals and Connectors are now available for wire (AWG 22 through 10) that conforms to any of the following military specifications.

MIL-W-7139A
MIL-W-16878A/5
MIL-W-16878A/6
MIL-W-8777 (USAF)
MIL-W-16878A/8

ask about amp's Creative Approach TO BETTER WIRING

A-MP

AIRCRAFT-MARINE PRODUCTS, INC

General Office: Harrisburg, Pa.

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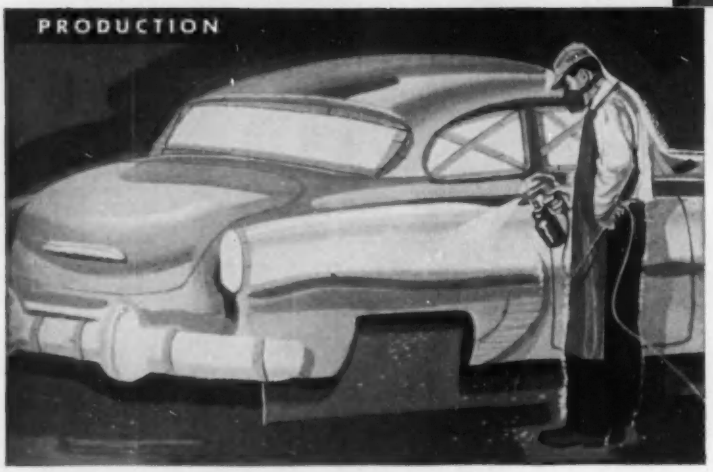
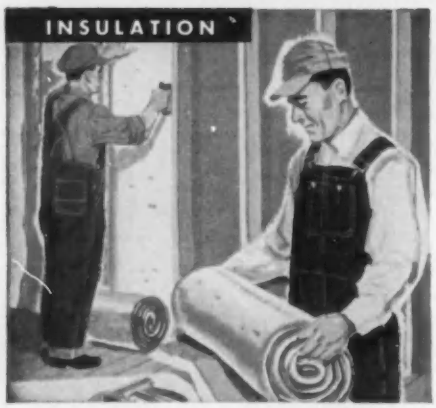
Is there a way to do it better - with paper?

Here are paper applications Mosinee helped develop for three industries— Good tip: they may suggest new uses for you!



Mosinee interleaving papers protect mirror-finish stainless steel. The presence of any foreign materials or surface imperfections would mar or scratch the metal's highly polished surface. Mosinee, through highly developed chemical and quality controls, produces these special papers with the required uniform properties.

Special Mosinee masking papers increase auto painting efficiency, reduce costs. These papers must have specific, controlled physical properties including high density and absolute freedom from pin holes to prevent paint penetration. Mosinee "know how" helped develop papers for this special application.



Flame-resistant paper by Mosinee makes good insulation better — safer. In this case, Mosinee flame-resistant paper is produced for the manufacture of home insulation bats. This exclusive Mosinee process may also be used with many types of paper for other products and may suggest a solution to your problem.

THESE applications are typical of the many instances in which Mosinee paper experts have cooperated with industry to develop special analysis papers to perform specific jobs. If your work involves costly or troublesome packaging . . . protection . . . insulation . . . lamination . . . fabricating . . . or processing — a specialized Mosinee paper may provide the answer you've been looking for.

For details on how to do the job better with papers by Mosinee, see your representative, or write —

MOSINEE PAPER MILLS COMPANY
Dept. PE. • MOSINEE, WISCONSIN

Mosinee

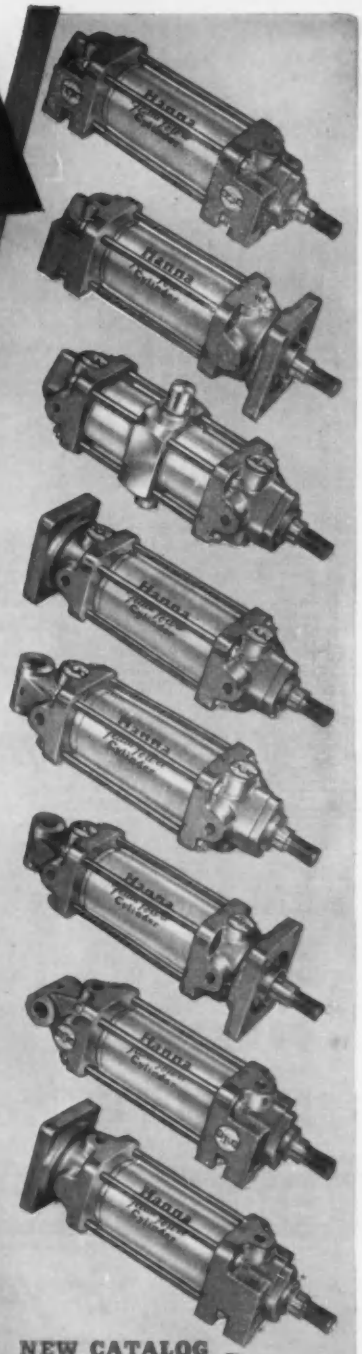
— specialist in industrial paper technology — makes fibres work for industry

Here's GREATER POWER for you ...in a MORE COMPACT DESIGN

FEATURES YOU WILL LIKE:

- Greater power from a more compact design.
- Resistance to corrosion throughout.
- Positive sealing with minimum friction loss.
- Materials selected for strength, durability and long cylinder life.
- Interchangeable heads and mountings.
- Conformation to J.I.C. Standards.
- Automatic compensation for rod packing wear.
- Built-in piston rod scraper to prevent dirt and abrasives from scoring rod or damaging packings.
- Adjustable cushions of unique design.
- Wide choice of operating pressures; Air to 250 psi; hydraulic to 750 psi.

The New HANNA T 750 Series Fluid Power CYLINDERS



● You'll find some unique and very interesting operating features in these new Hanna **T750** Series Fluid Power Cylinders . . . features that will help you solve many of your cylinder application problems more easily and more simply. The new Hanna **T750** Series comes in a range of capacities, sizes and mounting styles—for air operation up to 250 psi and hydraulic operation up to 750 psi.

For details, ask your Hanna Representative (see your classified telephone directory), or write today for a copy of the new **T750** Fluid Power Cylinder Catalog. No obligation.

NEW CATALOG
Write for Catalog 750A—it gives complete details.

Hanna Engineering Works

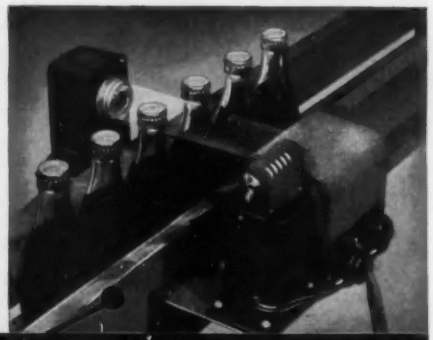
1763 Elston Avenue, Chicago 22, Illinois

FAST PUMPING WITH VIKINGS
in EITHER DIRECTION

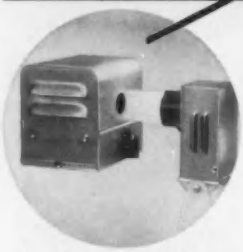
TRI-PAR Oil Company, Saukville, Wisconsin, makes good use of Viking Pump's reversible feature. The pumping system has a single suction line and a single discharge line which can be operated in either direction, eliminating the piping manifold. Speeded to deliver 325 G.P.M. the pumps can unload transports to storage and load delivery trucks from storage by merely reversing action.
Pumping units have lost no time from their operation during the three years they have been in service, and have handled approximately 25,000,000 gallons of gasoline and fuel oil in that period.
Perhaps Viking Pumps can speed your operation and simplfy your pumping. Types and sizes for most industrial pumping. For information, write for Bulletin 56Sx.

VIKING PUMP COMPANY
Cedar Falls, Iowa, U.S.A. In Canada, it's "ROTO-KING" pumps
See our catalog in Sweets

have you a similar counting problem?



PE-150 RIPLEY Photo-Electric CONTROL
is your answer!



Hammertone gray steel housing. Only 4" high. Operates on 110 volts, 60 cycle AC.

Here's an accurate, efficient, automatic control that anyone can easily install. Simply plug into your current supply and you are ready to count objects from corks to barrels — even hot or freshly painted objects — as they interrupt the beam of light.

HUNDREDS OF USES — EASY TO APPLY
It's easy to apply the PE-150 for any specific application such as controlling, signalling, sorting, counting, weighing, safeguarding operators, burglar alarms, attendance counts, and many other applications.

WRITE FOR BULLETIN PE-150

RIPLEY ESTABLISHED 1934
RIPLEY COMPANY, INC. MIDDLETOWN, CONN

been in conflict with those of the officers of a corporation. But it seems reasonable to me that the officers of a corporation will be interested in developing and maintaining a standard which will produce future business. Is the incentive to cut costs or do a questionable engineering job any greater in a corporation than in a partnership? Is it a fact that engineers who work for a corporation have lower professional standards?

The progress report of the EJC-ECPD Joiat Committee on the Practice of Engineering emphasizes the importance of the individual: "Professional responsibility for engineering work is a personal responsibility and that personal responsibility should be recognized by all laws relating to the registration or licensing of the professional engineer. Therefore, the person or persons in responsible charge of professional engineering practice must be legally registered professional engineers and there should be no discrimination by implication, omission, or direction as to the form of business organization, individual, partnership, corporation or other."

Characteristics of Thermally Sensitive Resistors

Abstracted from "Characteristics and Applications of Thermally Sensitive Resistors, or Thermistors" by J. W. Howes, Standard Telephones and Cables Pty. Limited; Sydney, Australia; *Electrical Communication*, June 1955.

Thermistors are made of thermally-sensitive resistance material in the form of small, bead-type elements, tubes, rods, blocks, disks, or flakes. Thermistor heating is achieved by passing current through the element, by an independent heater insulated from the element, or by placing the element in a heated enclosure such as an oven. Resistance (R) of a thermistor decreases with increasing absolute temperature T (Fig. 1) according to the approximate expression $R = a \exp (b/T)$, where R is the resistance at temperature T in deg K and a, b are constants depending on composition of thermistor material.

The temperature coefficient, $-b/T^2$, decreases with increasing temperature;

(Continued on page 382)

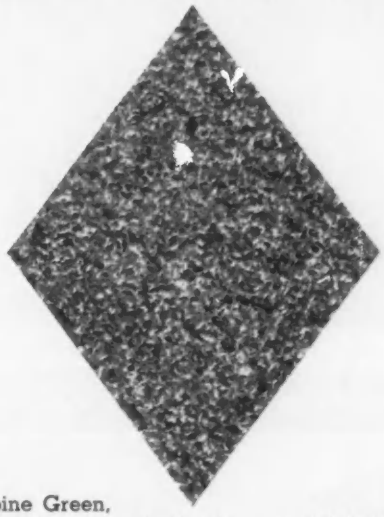
THE MOST AMAZING FINISH DEVELOPMENT IN 100 YEARS!

M. & W. CO.

COLOR-FLECKED **PLEXTONE®**

SINCE 1876

Imagine — a textured *and MULTICOLORED* finish — sprayed at *one* time, from *one* gun, in *one* coat that covers surface flaws and blemishes completely!



PLEXTONE Alpine Green, one of many standard pre-mixed colors available for prompt shipment. Also available in solid colors and in custom multicolors.

CAPSULE FACTS

WHAT IS COLOR-FLECKED PLEXTONE?

A completely new multicolored industrial finish in which colors exist separately. When sprayed, they form an interlacing color network of amazing beauty and durability.

CHARACTERISTICS

Lacquer base • Air dries approx. 30 minutes — dries hard 2 to 3 hours • Available in flat or semi-gloss • Exceptional hiding power — hides surface imperfections, covers porous materials • Remarkable abrasion resistance • Good chemical resistance • Does not stain • Can be scrubbed, even scoured • Quick and easy touch-up, without showing • Available in non-toxic grades • Bonds readily to primed wood, metals such as cast iron, steel, aluminum, brass, copper, zinc; also plastics, woven fabrics, wallboard, paper, cement, plaster, papier-mache forms.

USES

Manufacturers from coast to coast are using PLEXTONE to finish such products as Caskets • Displays • Furniture • Kitchen cabinets • Machinery • Office panels and partitions • Sewing machine tables • Silver chests • Signs • Store fixtures • Switch gear housings • Table lamps and shades • Toys • TV cabinets • Wallboard

PLEXTONE — CUTS FINISHING COSTS UP TO 35%

PLEXTONE often eliminates many pre-finishing steps on wood or metals. Usually no more than one coat of primer and one PLEXTONE coat are required! And PLEXTONE's texture hides wood knots, metal weld marks, flaws and blemishes.

PLEXTONE — AN UNBELIEVABLY RUGGED FINISH

PLEXTONE's color flecks go "through-the-film"! Resists chipping, cracking and abrasion . . . defies alcohol, grease, and oil! So tough, it can be washed, scrubbed, even scoured with abrasive cleansers without surface damage!

PLEXTONE — DRAMATIC SALES APPEAL OF *MULTICOLOR!*

Color-flecked PLEXTONE offers endless new effects . . . from subtle tones-on-tone to brilliant spatter-dash . . . two, three or more colors sprayed from one gun at one time! New sales appeal for any and all products.

PROVE IT TO YOURSELF —

Mail Coupon Today—Send for FREE color chips. See some of the many color combinations possible. Mail coupon NOW for FREE color chips, PLEXTONE sample and complete application data.

MAAS & WALDSTEIN CO.

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Midwest Division: 1658 Carroll Ave., Chicago 12, Ill.

Pacific Coast Division:
Smith-Davis Company, 10751 Venice Blvd., Los Angeles 34

PIONEERS IN PROTECTION • OUR 80th YEAR

PLEXTONE®

MAAS AND WALDSTEIN CO., PLEXTONE DIVISION
2133 McCarter Highway, Newark 4, New Jersey

Gentlemen: Please send me FREE color chips, PLEXTONE sample, and application data.

I am particularly interested in PLEXTONE for finishing_____

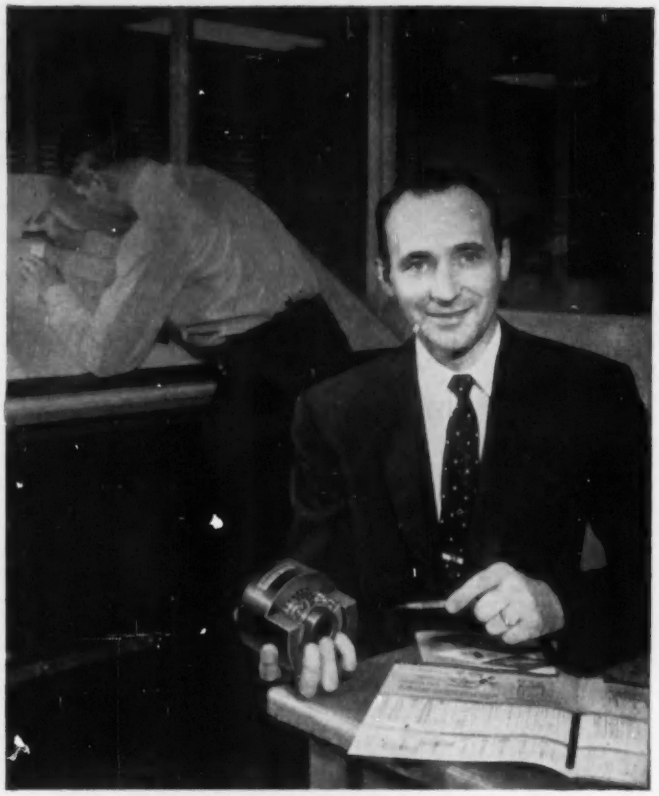
Name_____ Title_____

Company_____

Address_____

City_____ Zone_____ State_____

A Formsprag Clutch can simplify the functioning of your design



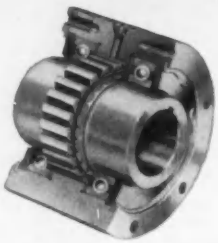
William T. Cherry, Mgr., Formsprag Application Engineering Dept.

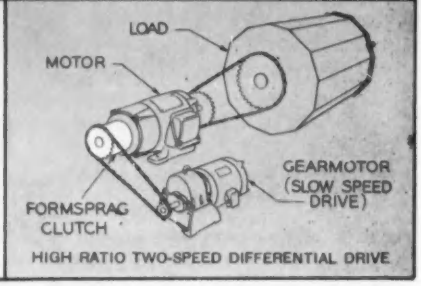
Designers are constantly finding ways to simplify the design of their products by utilizing Formsprag's higher torque capacity and precision. Over-running, indexing, and backstopping applications are almost unlimited.

The modern, patented design of Formsprag Clutches is the secret. Each clutch—designed with utmost simplicity—offers the highest possible torque capacity in an extremely small area. And, you get rugged, precision performance with long life.

The next time you're thinking of maximum clutch efficiency for your product—remember these principles about Formsprag Clutches:

How Formsprag's simple, precision design works for you





HIGH RATIO TWO-SPEED DIFFERENTIAL DRIVE

Sprags used in Formsprag Clutches are highly developed, precision wedges of hardened alloy steel. Due to the sprag's design, an unusually high amount of torque is delivered from one concentric race to the other. When torque is applied, the sprags are instantaneously engaged. When torque is removed, the sprags release instantaneously.

Basic construction of the Formsprag Clutch is simple. A full complement of sprags is inserted between inner and outer concentric races. Contact with both race surfaces is maintained by energizing springs. Formsprag construction allows more sprags to be inserted in a smaller area than other clutch designs. Result: greater torque capacity in a smaller clutch.

See Booth #316 at the Design Engineering Show

Here is a typical over-running arrangement on a two-speed drive: The clutch transmits power during the low speed cycle while the high speed motor acts as a countershaft and transmits power to the load. During the high speed cycle, the over-running clutch permits the low speed motor to be over-run. This arrangement is particularly economical and efficient where the speed differential required is too great for a two-speed motor.

Formsprag's engineering department has solved literally thousands of clutch application problems—using either standard or specially designed clutches. For further information, send for this informative eight-page brochure or contact Formsprag direct.

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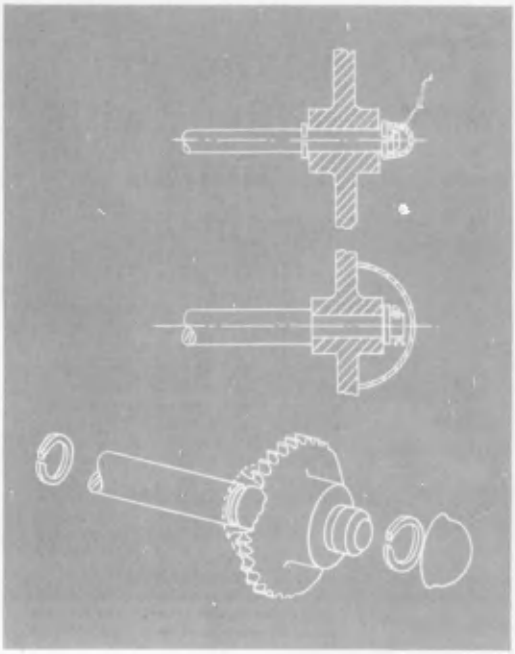

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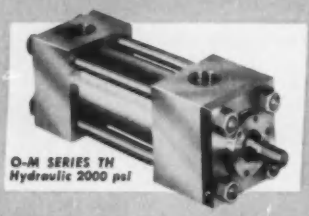

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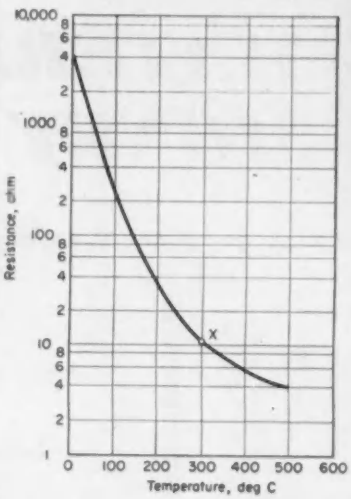


FIG. 1—Characteristics of type F2311/300 thermistor developed for thermometry. R_c=2000 ohm at 20 C. Point X marks the maximum operating temperature.

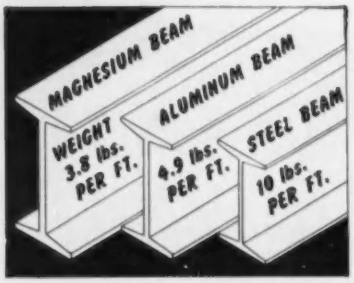
its value is usually of the order of 3 to 4 per cent per deg C at 20 C compared with about +0.35 per cent per deg C for platinum. Thermistors are available with standardized values of cold resistance between the limits of 500 and 500,000 ohm.

Heater-coil resistance of indirectly heated types is generally 100 ohm; heater efficiency is the ratio between the power dissipated in heater in order to reduce thermistor resistance to 2 per cent of cold value. Typical heater efficiency is approximately 90 per cent. Thermistor resistance-changes with heating power can be specified either as percentage change of resistance for one deg C change or by a statement of "half-temperature" or a figure derived from this. Half-temperature is temperature change in deg C necessary to halve or double the cold or stated initial resistance.

The thermistor characteristic shown in Fig. 1 has a half-temperature of 18 C at 20 C, whereas at 200 C the half-temperature is 45 C. At the higher temperature, the resistance is a fraction of its cold resistance and a 45 C change is required to further halve the resistance; this factor sets one limit to the useful range of thermistor operation.

Thermistor power sensitivity is defined as the rate of temperature change with power input and is expressed in

(Continued on page 386)



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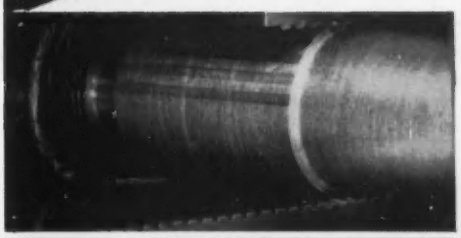
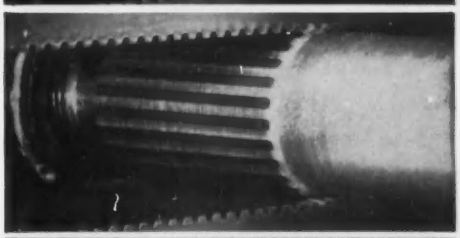
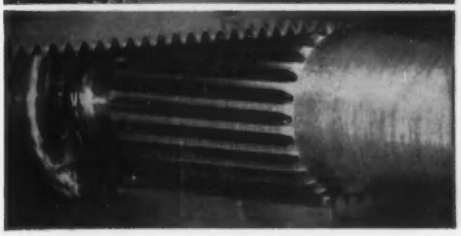
. . . designers are SPECIFYING toothed parts formed by ROTO-FLO







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deg C/mw. This characteristic depends on mass of resistance material, the method of mounting resistance element and other factors. Relation between power sensitivity and power input is approximately linear over the first 50 C rise from room temperature. Table I shows power sensitivity of one manufacturer's thermistors. Block type (K and KB) are relatively power insensitive and suitable for use as ambient-temperature compensators. When power is dissipated by a thermistor it becomes hotter and resistance decreases with increase of power input; when ambient temperature falls, a greater input is required to reduce resistance to any particular value.

For example, a power input of 1 milliw increases temperature of a bead-type thermistor formed on platinum wires by 3.5 C; to maintain thermistor resistance 1 milliw for each 3.5 C fall in ambient temperature must be dissipated. Power input must not exceed the maximum for continuous use; for periods up to 1 min it is usually safe to exceed max rating by 50 per cent. In indirectly heated thermistors, total power dissipation in bead and heater must not exceed maximum indicated. If thermistor temperature is maintained thermistor obeys Ohm's law and the relation between voltage and current is linear.

Dissipation constant is the reciprocal of power sensitivity and is the power input necessary to raise the temperature of the element by 1 C.

The voltage and current characteristics are of considerable importance (Fig. 2). As the current through a thermistor is increased, the voltage across it rises rapidly at first and soon attains maximum value E_{max}. Thereafter, there is a rapid drop in voltage with further increase in current. As the current increases, the rate of fall of voltage decreases and may, under suitable conditions, remain fairly constant over a wide range of current.

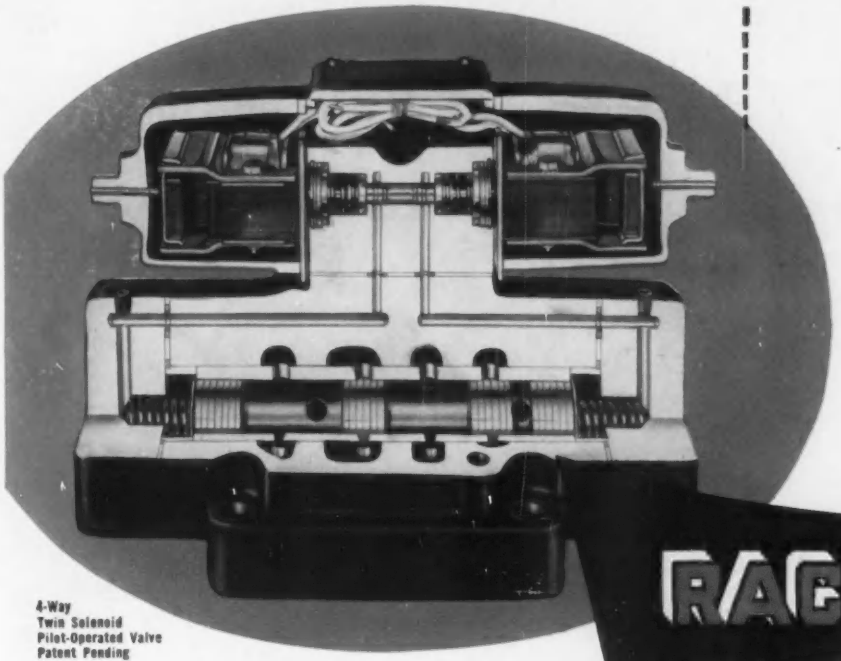
An approximate value of E_{max} for any thermistor can be calculated from:

$$E_{max} = (R_c)^{1/2}/K,$$

where R_c is resistance at ambient temperature, K as maximum-voltage factor, dependent only on ambient temperature and the type of thermistor.

For a thermistor at ambient temperature of 20 C, resistance of 50,000

(Continued on page 390)



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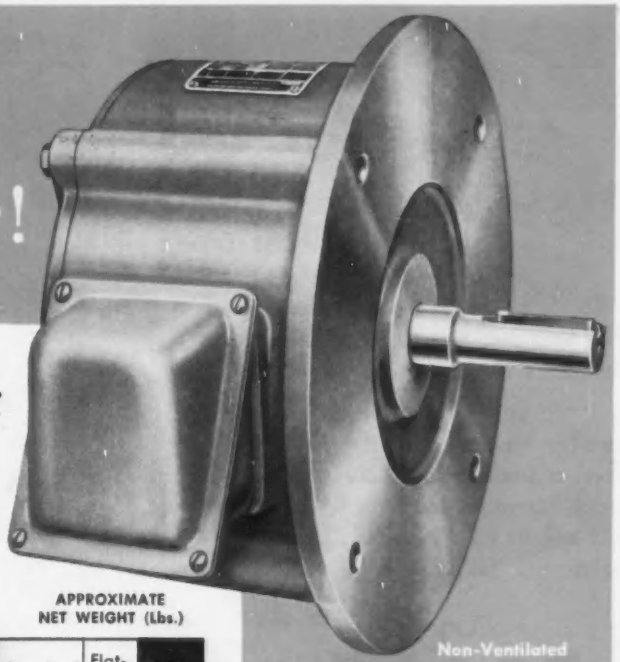

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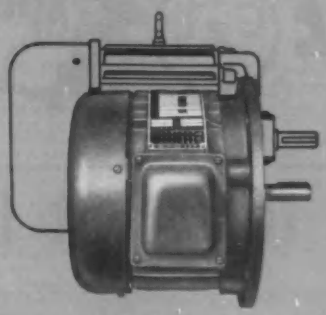
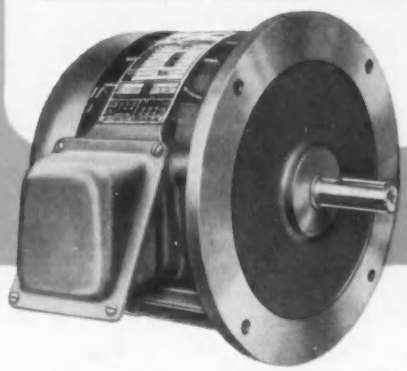
DIF 213	DIF 220	17 3/16	11 9/16	5 5/8	128	83	45
DIF 284U	DIF 280	26	13 13/16	12 3/16	272	135	137



New Flat-Type superimposed on standard motor



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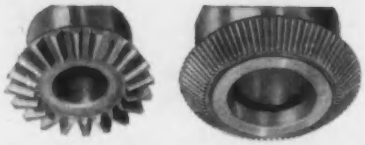

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Coniflex Straight Bevel Gears in effect have a crowned tooth. Therefore, a small displacement of gears under operating loads is possible without concentration on the ends of the teeth.

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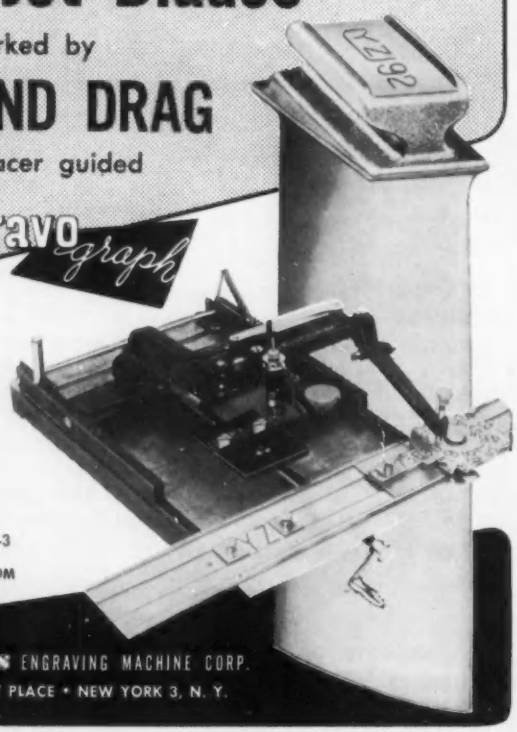

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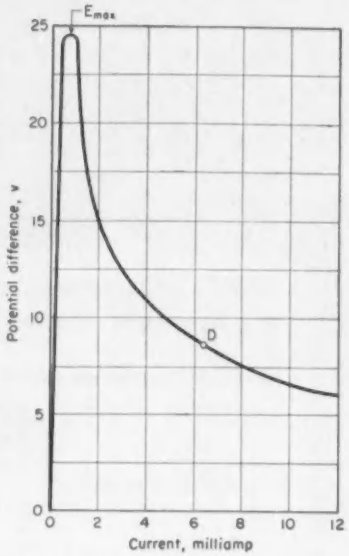


FIG. 2—Typical thermistor voltage-current curve. R_c=100,000 ohm at 20 C. Negative-resistance between E_{max} and point D may be put to use.

ohms and max voltage factor of 20, value of E_{max} is

$$(50{,}000)^{1/2}/20 = 11 \text{ v, approx}$$

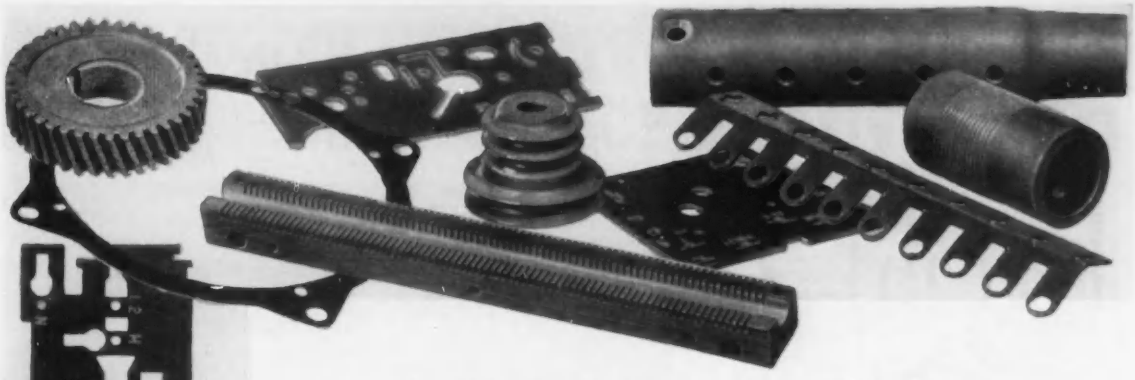
Time constant of an indirectly-heated type is the time taken for the logarithm of thermistor resistance to change by (e − 1)/e 63 per cent of final change) when heating power is suddenly applied or removed. It is usual to measure time constant for a change of heating power applied until equilibrium is reached, which halves or doubles the resistance. In high-vacuum types, time constant for decrease of heating power is longer than for heating; in gas-filled, heating and cooling time constants are more nearly the same, and are shorter. Average time constant of a type-B thermistor is 3 or 4 sec, while that of the type L is 1 to 2 sec.

Transient behavior of a directly-heated thermistor will vary from circuit to circuit, depending on manner in which dissipation changes with thermistor resistance. The following rules are a guide to operating conditions under which a thermistor will give good service.

A. Potential applied to thermistor element must not exceed E_{max} when circuit series resistance is less than 1.25 per cent of the cold resistance.

B. Potential applied to thermistor

(Continued on page 395)



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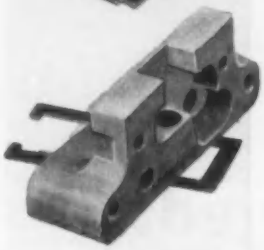

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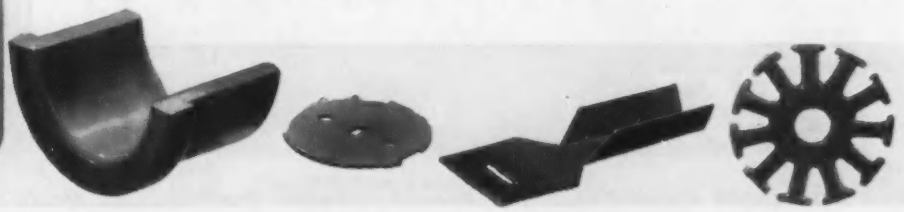

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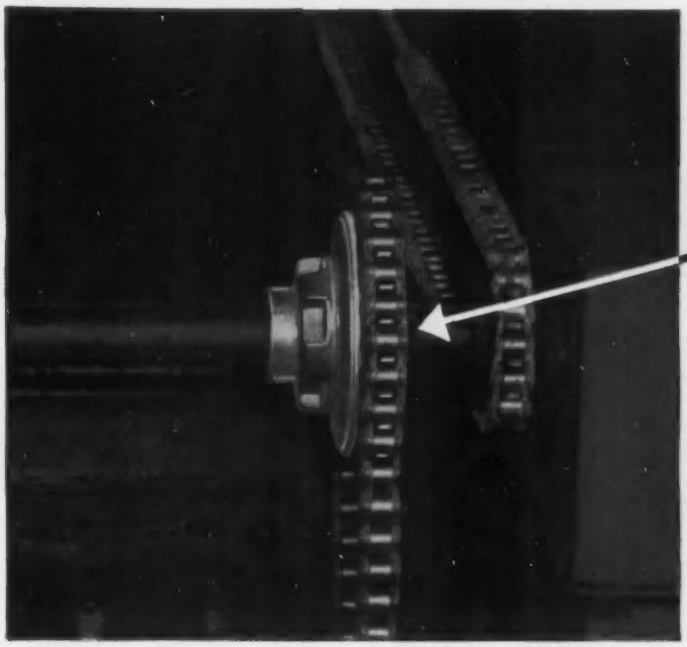
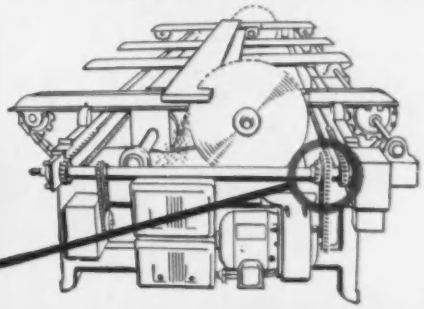
MORSE TORQUE LIMITER PROTECTS MOTOR AND REDUCER FROM DEAD-STOP OF DRIVEN UNIT!





Morse Torque Limiter and sprocket act as slip clutch on Model 55 Automatic Electric Shift Trimmer made by The Wheland Company, Chattanooga. Arbors are shifted at 120 fpm, instantly stopped and locked into place. Torque Limiter on jackshaft is set so sprocket slips when motor torque (38 ft.-lbs.) is exceeded. Absorbs inertia of 1-hp, 155-rpm gearmotor; reduces shock on drive unit when driven shaft is stopped.

Typical application shows how you can safeguard drive units and eliminate shear pins

Check these advantages of Morse Torque Limiters

- √ Eliminate downtime
- √ Torque-sensitive and fully adjustable
- √ Completely automatic and dependable
- √ Resume operation automatically
- √ Compact, standard sizes

In this Wheland Electric Shift Trimmer, two 200-pound saw arbors are automatically moved into position at 120 feet per minute . . . then stopped dead and locked into place.

The tremendous shock transmitted to the drive mechanism when the arbors are stopped, is safely dissipated by a Morse Torque Limiter used as a slip clutch between the driving and driven units. In addition, it prevents motor inertia from building up torque in the drive.

Versatile Morse Torque Limiters can safely control many of the shock-load problems present in your machine operations.

These simple devices are dependably sensitive and easily adjusted to desired torque limits. When overload or jam-up is cleared, they automatically resume operation, eliminating downtime or dismantling necessary with shear pins.

Send for Free Catalog

A full line of Torque Limiters is stocked by your Morse Distributor. For free catalog, or power transmission engineering help, see him or write today.

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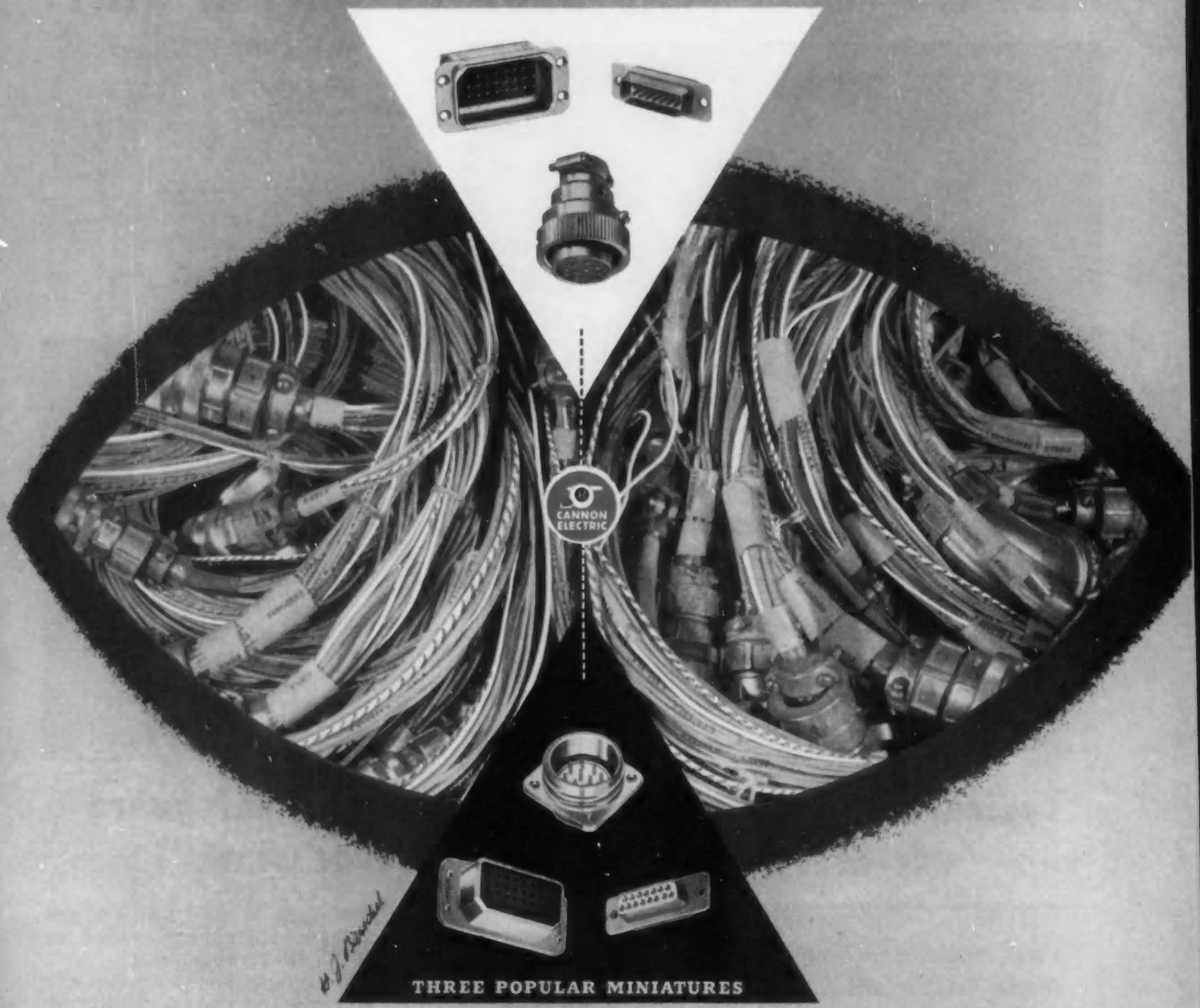
POWER TRANSMISSION PRODUCTS

The MATERIAL HANDLING INSTITUTE'S EXPOSITION
Cleveland, Ohio
PUBLIC AUDITORIUM
JUNE 5th THRU 8th, 1956
BOOTH 1201

Experience has shown that connector problems fall into three main classes —(1) Selection of the most suitable connector from those cataloged— (2) Modification of an existing type or the use of a non-cataloged "special"—or, (3) Design and use of a new type or series.

MINIATURES AND SUB-MINIATURES



THREE POPULAR MINIATURES

connector problems?

The first problem may best be met by the use of Cannon Electric Condensed Catalogs (ICC and RJC) plus the Plug Guide (CPG) and the small 8-page Guide which are keys to the various engineering bulletins on such types as AN (MIL Specification), Miniature, Rack/Panel/Chassis, Audio, etc. If modifications are required, consult your local Cannon Representative who in conjunction with factory sales engineers, constantly is making adaptations to fit special needs. New designs are always being considered, designed, and developed by Cannon Electric. For those whose requirements are "off-trail," a *"Connector Requirements Sheet,"* fully filled in, will save time and effort in arriving at a suitable design. We will gladly send this sheet upon request, plus the new Miniature Bulletin, or the other bulletins.

Please refer to Dept. 106

CANNON PLUGS

CANNON ELECTRIC CO., 3208 HUMBOLDT ST., LOS ANGELES 31, CALIFORNIA

WORLD'S LARGEST EXCLUSIVE MANUFACTURER OF ELECTRIC CONNECTORS FOR INDUSTRY

element must not exceed 2 E_{max} when circuit series resistance is greater than 1.25 per cent of thermistor cold resistance.

C. Maximum power that may be continuously dissipated is indicated by maker. For periods up to 1 min, this figure may be exceeded by 50 per cent.

The large temperature coefficient of resistance (approximately 10 times that of platinum) makes possible very sensitive thermometers. One thermistor thermometer indicates changes of 0.0005 C. High thermistor resistance makes long leads effects negligible in most cases and small thermistor element can be usefully employed for remote indication using a relatively inexpensive d-c current meter for an indicator. Temperature measurements of intravenous blood, supercharger rotors, and insertion of tiny bead thermistors into journal boxes, gear housings and power transformers during construction are examples of this type of use.

A thermistor developed for thermometry, has a small mass of thermistor material fused into the glass tip of an evacuated bulb; it responds almost instantly to temperature changes.

Fig. 3 shows a simple circuit using a thermistor for direct temperature indication. The calibration curves

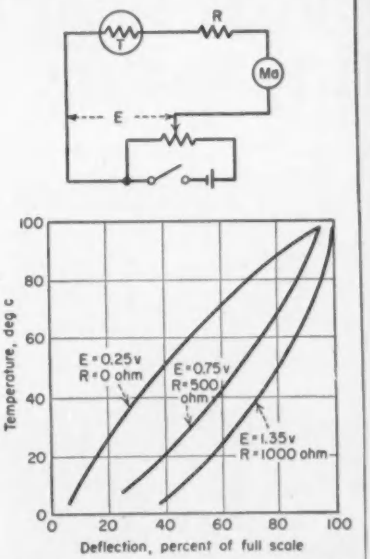


FIG. 3—For thermistor thermometer circuit. R_c=1000 ohm at 20 C. The 1-milliamp meter has a 100 ohm resistance. Characteristic curves are given below.

(Continued on page 398)

DESIGNERS and DEVELOPMENT ENGINEERS
HAYDON makes very small, extremely rugged Timing Motors for 60 cycle, 400 cycle, and d-c use. They precisely, dependably measure and control timing — under variable conditions . . . in unusual locations and positions . . . without taking up too much space! With the help of HAYDON Timing Motors, you can now build time controls into your product with a minimum increase in space requirements!
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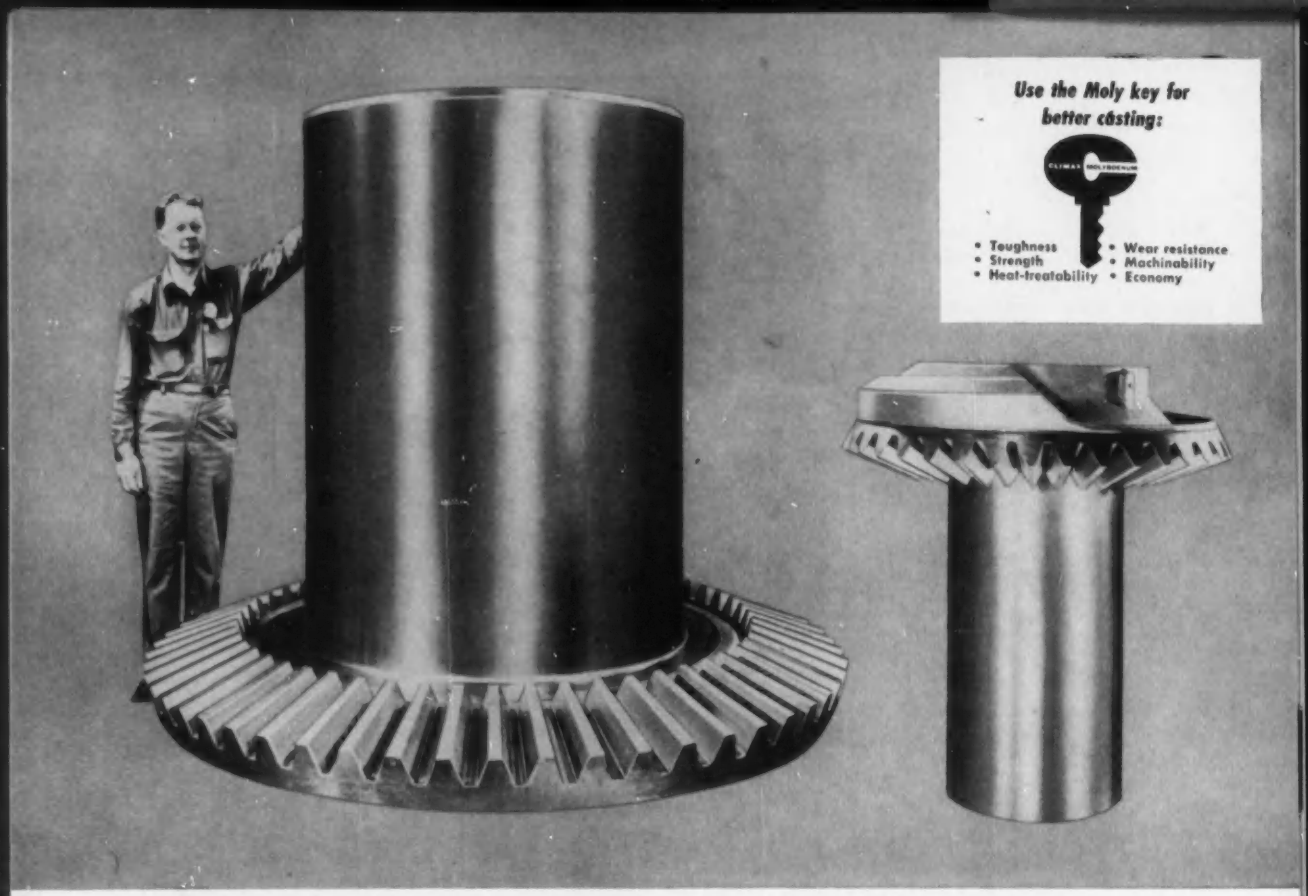
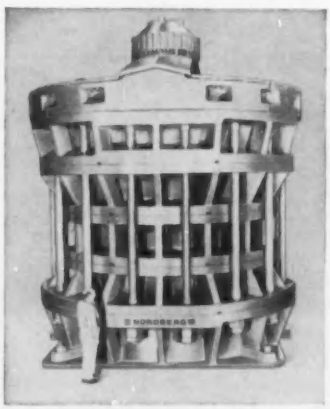


Heavy duty ore crushing machinery is subjected to severe operating conditions. To meet these strenuous requirements the gears shown are made from heat treated low-alloy manganese-*Molybdenum* steel castings. At left: a Symons Gyratory Crusher gear; right: a Symons Cone Crusher gear. Built by Nordberg Mfg. Co.

Cast Manganese Moly Steel contributes strength and toughness to Crushers built by Nordberg

"Where high strength and toughness are prime considerations," says Howard Zoerb, Consulting Engineer of the Nordberg Crusher Division, "molybdenum bearing steels are specified. This is true of the heavy duty parts of Symons® Crushers, built by Nordberg. These steels have contributed to the Nordberg reputation as producers of dependable, heavy duty crushing machinery."

Technical assistance is available to foundries on alloying problems. Please address inquiries on your foundry letterhead to: Climax Molybdenum Company, Department MF61, 500 Fifth Avenue, New York 36, New York.



The Symons Cone Crusher is a product of Nordberg Manufacturing Company.

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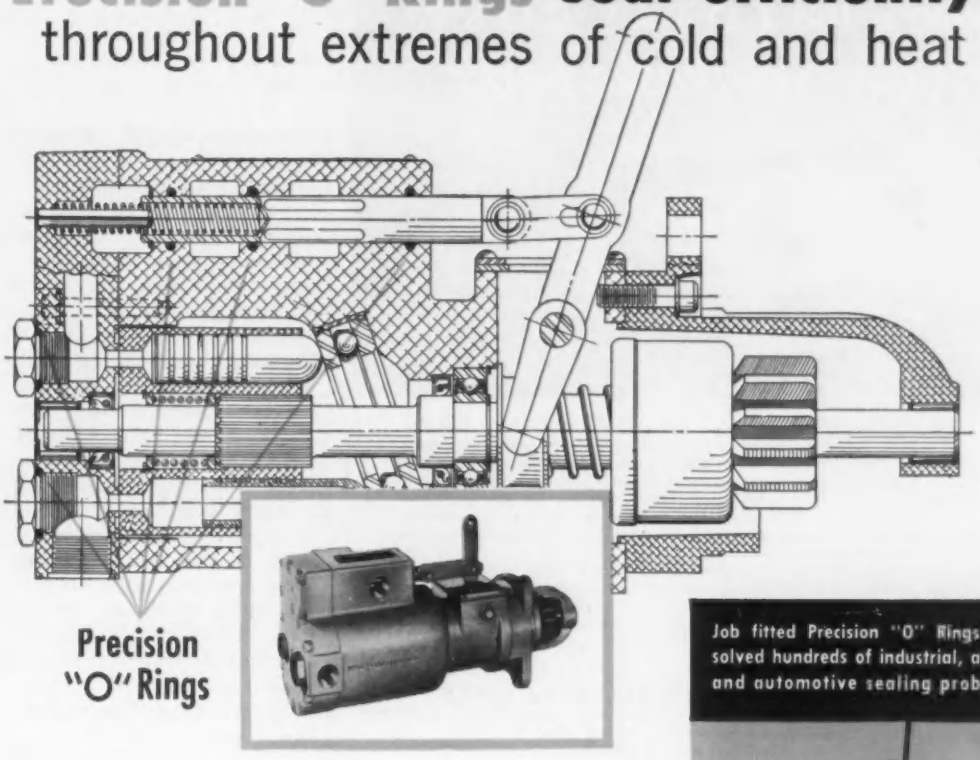
Precision "O" Rings **seal efficiently** throughout extremes of cold and heat



The Hydrotor Hydraulic Cranking Motor, manufactured by Hydramotive, Inc., Cleveland, Ohio, provides high cranking torque and adjustable speeds over a temperature range of −65° to +165° F.

Hydramotive, Inc., standardized on Precision "O" Rings after exhaustive competitive tests. Precision "O" Rings guaranteed long life sealing and flexibility in arctic cold.

Precision "O" Rings are compression molded from quality controlled compounds. They're the finest made! Rigid inspection and engineering skill assure long life, leak proof sealing. Precision can furnish the size and compound that fits your requirements and "O" rings that meet all military and commercial specifications.

What is your sealing problem? There is an expert—the Precision engineer—ready to help you in product design. Rely on Precision, the world's largest exclusive producer of "O" rings.

Job fitted Precision "O" Rings have solved hundreds of industrial, aircraft and automotive sealing problems.

Precision "O" Rings meet military specifications and were used in the North American F-100C Super Sabre.

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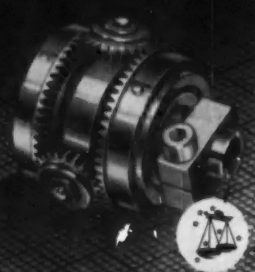


This Librascope precision computer component has only 10 min. backlash. Hollow shaft eliminates stocking custom shaft lengths in breadboard work and cost reduction in production assembly operations. Small size, low inertia, precision ball bearings, 3 point contact with spider gears. Can be installed or removed without disassembly of differential or instrument. Write *for catalog information.*

SPECIFICATIONS:
Inertia: .074 oz.-in.
Max. Backlash: 10 min.
Axial length: 1-3/16"
Clearance radius: .545"
3/16" dia. shaft
Weight: 1¼ oz.

Computers and Controls
LIBRASCOPE
A SUBSIDIARY OF GENERAL PRECISION EQUIPMENT CORPORATION

LIBRASCOPE, INCORPORATED
1607 FLOWER ST., GLENDALE, CALIF.

show how scale linearity and possible range of temperature measurement can be controlled by changing battery voltage and value of series resistance.

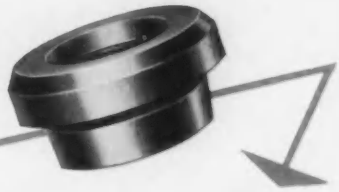
An object may be ordinarily inaccessible to direct temperature-measuring devices, either through physical position, because it is in motion, or it may be too hot for contact thermometry. In such cases, temperature may be determined by permitting radiation from the object to be focussed on a suitable thermistor. An example is an infra-red bolometer developed during the war which utilized a flake thermistor so sensitive that it would detect the warmth of a human being a quarter of a mile away. Another example is a method used by a tin can manufacturer to measure temperature of soldered seams while 350 cans per min. move past on conveyor belt. An optical system was arranged to focus radiant energy from the cans on a flake thermistor; variation in the amount of energy radiated as the cans moved past line of sight of the optical system was sensed by the thermistor. The resulting signal voltage, suitably amplified, was presented as a pattern on a cathode-ray oscilloscope.

The negative temperature coefficient of thermistors may be used to compensate for positive temperature coefficient of metallic conductors such as copper wire in coils or transformers. Over a small range of temperature the coefficient is linear but it decreases with increasing temperature, as shown in Fig. 1.

In simplest form, the temperature-compensation circuit consists of a metallic resistor and a thermistor in series; any increase in the value of the resistor due to a rise in ambient temperature is compensated for by the thermistor, which is subject to same ambient temperature. The temperature coefficient of copper is 0.4 per cent per deg C; that of a typical thermistor may be −4 per cent per deg C, so that if a thermistor having one tenth the resistance of the copper wire is placed in series, compensation will be obtained over a narrow range; such a simple arrangement is not entirely satisfactory. However, by shunting the thermistor with another resistor, good compensation may be obtained over a reasonable temperature range. Resistor used in parallel with

(Continued on page 402)

for those
"HARD-TO-REACH"
Places!



Lamson PLUG NUTS

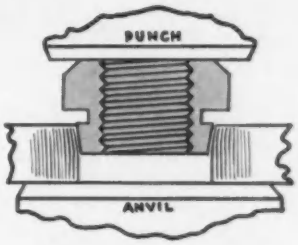
The advantages of Plug Nuts are many-fold. Both the designer and the production man will find they can solve many special fastening problems that cannot be solved in any other way.

For instance, Plug Nuts are the ideal solution to "one way" fastening where it is difficult or impossible to work from both sides of the assembly.

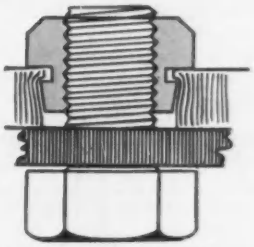
Plug Nuts can often eliminate or simplify machining operations, improve the product, simplify design or reduce assembly, and hence, labor costs.

If you have an application where you think you might use Plug Nuts, send us the size required, or details of the application, and we'll be happy to send sample nuts for trial.

For additional detailed information send for the Lamson Plug Nut Brochure.



SEATING PLUG NUT IN HOLE



PLUG NUT SEATED AND BOLT TIGHTENED DOWN

PLUG NUT SIZES AND TYPES

Plug Nuts are available in sizes ranging from #4 to ½" diameter—fine or coarse threads. Plug Nuts work in copper, brass, magnesium, aluminum, steel, alloy steel castings (die and sand) and forgings.

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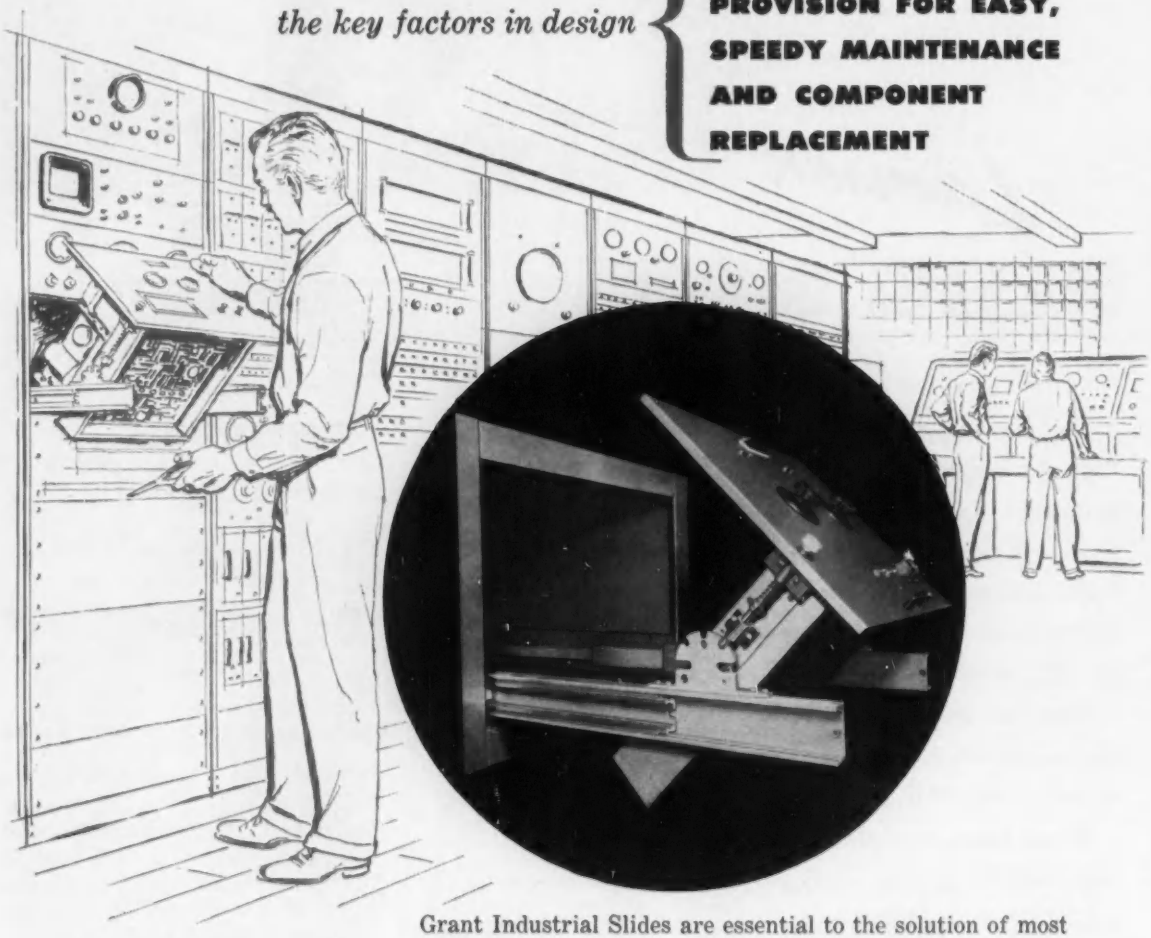

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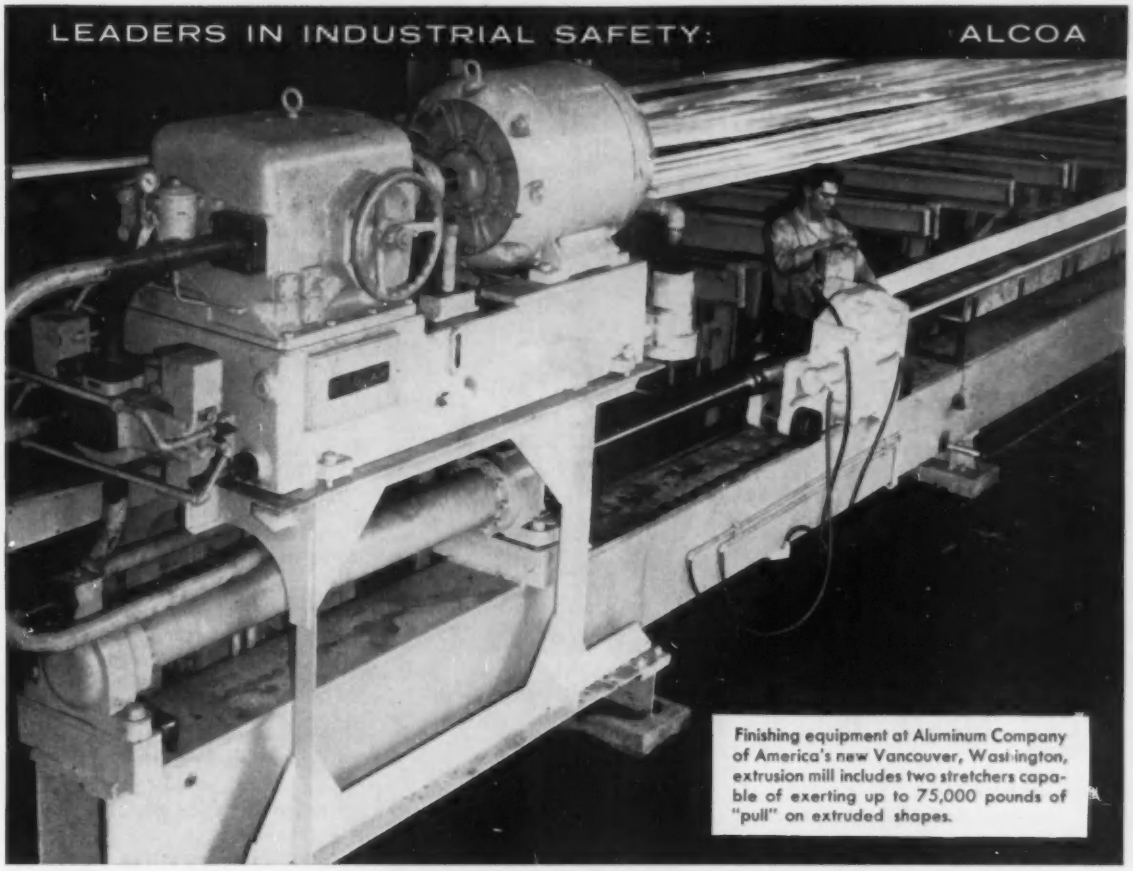
LEADERS IN INDUSTRIAL SAFETY: ALCOA



Finishing equipment at Aluminum Company of America's new Vancouver, Washington, extrusion mill includes two stretchers capable of exerting up to 75,000 pounds of "pull" on extruded shapes.

One of the things that impresses visitors to Alcoa is the strong emphasis on safety. It isn't surprising, then, to find fire-resistant Pydraul used in Alcoa hydraulic equipment... eliminating a potential source of fire.

FIRE-RESISTANT PYDRAUL F-9 CHANGES FIRE ZONES TO SAFETY ZONES

275 million hours of actual in-use operation—without a single hydraulic fire—*proves* the safety and dependability of fire-resistant Pydraul hydraulic fluid.

But Pydraul gives you more than safety. You can be sure of long equipment life with low maintenance . . . because Pydraul lubricates like a premium petroleum oil. You'll save money on fluid consumption, too! Pydraul is reclaimable—you can return spillage to the system, use it again and again.

Make a quick check of your hydraulic equipment . . . calculate your fire risk if it's close to hot metal, electrical contacts, open flame or other heat sources. Then talk to a Monsanto representative. He will show you how easy it is to convert to Pydraul . . . giving you a future of positive safety from hydraulic fires . . . at low cost per year.

PYDRAUL MEANS:

Fire Resistance
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Write now for new booklet, "PYDRAUL F-9." Organic Chemicals Division, MONSANTO CHEMICAL COMPANY, Dept. PYD-1, St. Louis, 1, Mo.

PYDRAUL F-9—First and Only Hydraulic Fluid Listed by Underwriters' Lab.

On May 31, 1955, Pydraul F-9 became the first fire-resistant hydraulic fluid listed by Underwriters' Laboratories. From the Laboratories' Service Card: "The fire hazard of (PYDRAUL) is rated 2 to 3 in accordance with Underwriters' Laboratories, Inc.'s Standard of Classification in which Ether rates 100, Gasoline rates 90-100, Alcohol (ethyl) rates 60-70, Kerosene (100° F. flash) rates 30-40, and Paraffin oil rates 10-20." See Underwriters' Laboratories, Inc.'s guide No. 540 18, File MH6049.

PYDRAUL: Reg. U. S. Pat. Off.

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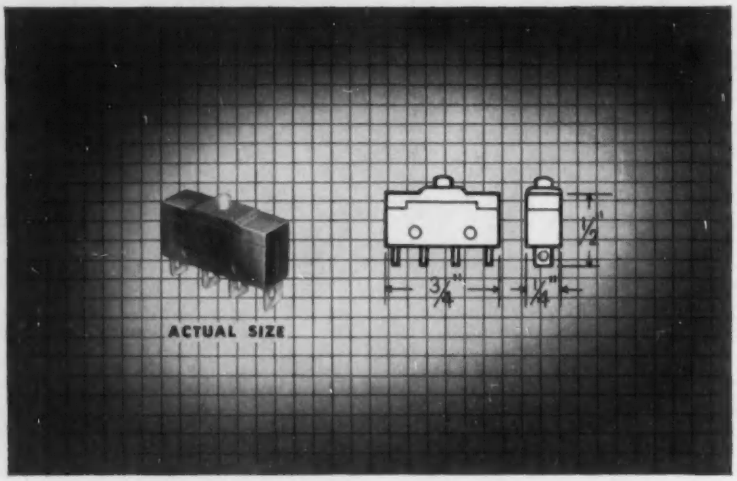

NEW Acro Subminiature Snap-Switch

- **HIGH ELECTRICAL RATING**—10 Amps at 115 volts or 230 volts A.C. or 28 volts D.C.
- **EXTREME TEMPERATURE RANGE**—from +350°F to −100°F
- **LONG MECHANICAL LIFE**—many millions of cycles, continuous duty
- **DOUBLE CIRCUIT TERMINAL ARRANGEMENT**

The big feature about this little switch is its high rating. It has *four times* the capacity of most switches in this size. And temperature extremes pose no problem. The Acro subminiature switch will operate within a range of from +350° to −100°F. Long life is assured through use of the rugged Acro rolling spring principle, up to 10 million cycles continuous duty.

High rated Acro subminiature switches are your answer to the problem of controlling big loads in confined areas. And on lesser loads their excess current-carrying capacity is a good safety factor. Four terminal construction permits wiring double circuits where required. The entire unit is housed in a plastic case and can be adapted to any present type actuator. Write for literature.

ACRO MANUFACTURING COMPANY
SWITCH DIVISION
Columbus 16, Ohio
Plants at Columbus and Hillsboro
REPRESENTATIVES IN PRINCIPAL CITIES

thermistor should have a low temperature coefficient if it is subject to same ambient temperature change.

Negative-resistance portion of the voltage/current characteristic shown in Fig. 2 can be used to provide trigger action. If sufficient current is passed through the thermistor to make the voltage across it equal to E_{max}, then any small increase of the current or the ambient temperature reduces the thermistor resistance, and resulting increase in current is considerable. The increase in current may be used to operate a control relay.

Trigger characteristic may also be used to provide a time delay switch; delay times from milliseconds to minutes are possible. The thermistor is wired in series with a relay; until thermistor reaches critical temperature, current rises slowly. At temperature corresponding to E_{max}, large increase in current occurs, operating the relay. Delay time is adjusted by a series variable resistor as well as by choice of thermistor time constant.

Thermistors used for surge suppression are connected in series with device to be protected; high initial resistance prevents any short-duration surge from operating the device, whereas the operating voltage, although of much lower amplitude, is applied long enough to cause thermistor heating and reduction of resistance to point at which device operates. An example is suppression of heater current surge in an a-c d-c radio receiver when it is switched on. The tube heaters are connected in series and supplied from power line through a voltage-dropping resistor. Cold resistance of heaters is as low as a quarter of hot resistance; large initial surge shortens tube life. A thermistor of 2000 to 3000 ohm cold resistance in series with the circuit reduces surge to less than 10 per cent overload; when hot, voltage drop across thermistor is low. Same principles can reduce starting current of small electric motors.

Industry Looks at the Engineering Shortage

Abstracted from "Industry Looks at the Engineering Shortage," by T. C. Gleason, Asst. Ch. Engr., Chrysler Corp.; presented at 24 Annual Meeting, American Society

(Continued on page 405)

IT'S CRITICAL

IT'S COMPLEX . . . . . IT'S FORGED

This critical jet engine "case ring" with its odd protrusions, thin section and large diameter, would have been a designer's dilemma a short time ago.

Today, Cameron's advanced forging technique, developed on some of the world's largest and most unusual presses for ferrous forgings, has opened new vistas of design, high production and economy.

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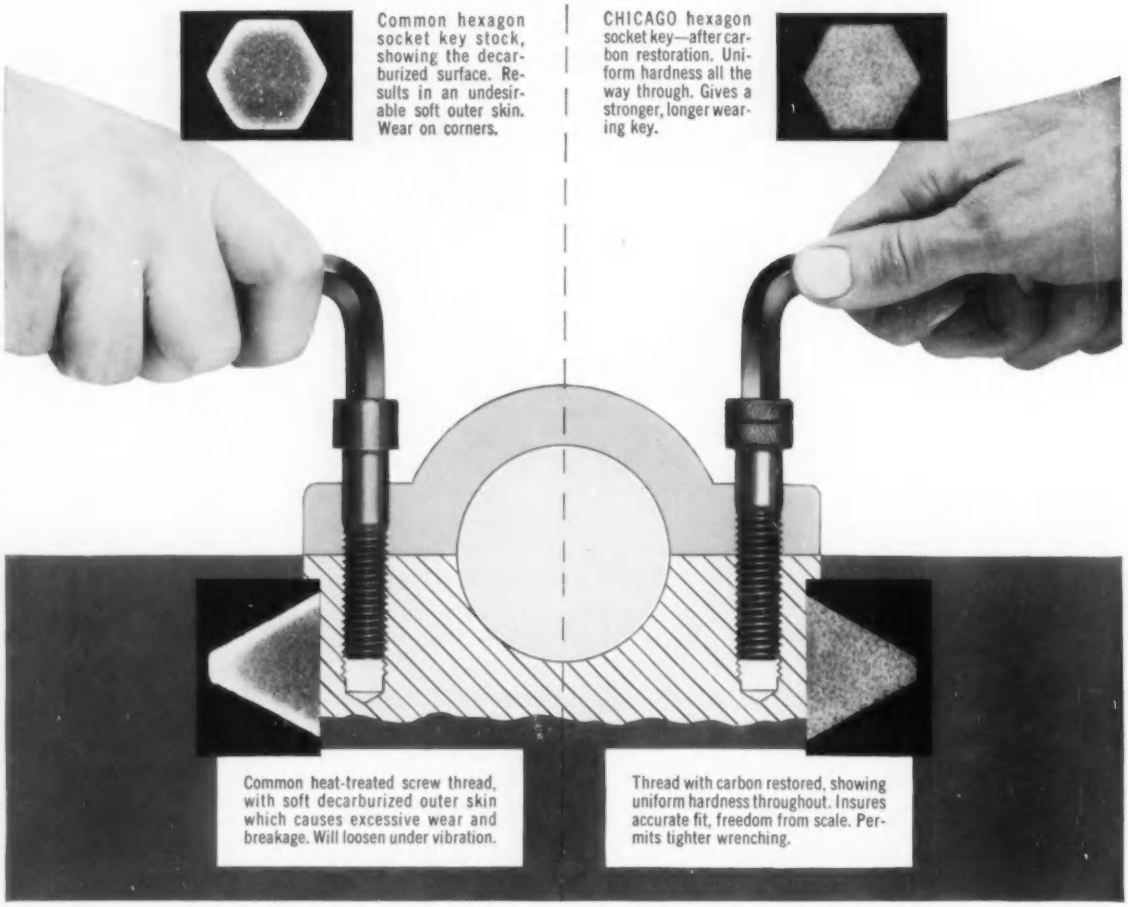
P. O. Box 1212, Houston, Texas

How carbon affects fastener performance

Screw fasteners may look identical, but the microscope reveals a wide difference in their ability to "take it"


Common hexagon socket key stock, showing the decarburized surface. Results in an undesirable soft outer skin. Wear on corners.
CHICAGO hexagon socket key—after carbon restoration. Uniform hardness all the way through. Gives a stronger, longer wearing key.
Common heat-treated screw thread, with soft decarburized outer skin which causes excessive wear and breakage. Will loosen under vibration.
Thread with carbon restored, showing uniform hardness throughout. Insures accurate fit, freedom from scale. Permits tighter wrenching.

The ability of a screw fastener to *stay* fastened depends to a great degree on its uniform hardness. And the hardness of steel hinges on the precise amount of carbon in its structure. However, during steel manufacture and processing, vital surface carbon is inevitably lost. As the above photomicrographs show, lack of surface carbon results in a soft outer skin in the finished fastener. Decarburized outer layers are the cause of many fastener problems: thread stripping, fatigue failure, excessive wear, loosening under vibration, soft corners on socket keys that turn off during use.

The soft "decarb" layer is eliminated by the unique *"Carbon Restoration"* process used by The Chicago Screw Company. In this process, surface carbon is replaced during heat treating, producing a fastener that is uniformly hard from core to surface! The amount of carbon restored is precisely controlled to give maximum hardness without excess carbon build-up. The *Carbon Restoration* process also results in bright hardening and freedom from scale.

All CHICAGO "Safety-Plus" Socket Screw Products and heat-treated cap screws have the benefit of *Carbon Restoration* plus complete quality control procedures from raw material to finished fastener. If you would like complete information and catalog, simply write our Standard Products Division.

THE CHICAGO SCREW COMPANY

DIVISION OF STANDARD SCREW COMPANY • ESTABLISHED 1872

2507 WASHINGTON BOULEVARD, BELLWOOD, ILLINOIS

of Tool Engineers, Chicago, Ill., March 19 to 23, 1956.

The Bureau of Labor Statistics recently reported that the nation's industries could use 40,000 engineers a year. Only slightly more than half that number were graduated this year.

In the face of rising demand, the output has declined. In the 1950-51 academic year, nearly 42,000 engineers graduated, or about 11 per cent of all graduates. In the 1954-55 year, only about 23,000 received engineering diplomas, or about 8.5 per cent of total graduates. This decline has hit all industries, those producing defense equipment as well as those engaged in consumer product manufacturing. Most of these graduates don't know the meaning of job-hunting. The jobs come hunting for them in the form of highly organized recruiting teams from every branch of industry.

These are obviously artificial—if not unwholesome—conditions. But I have absolutely no criticism of the young engineers whose heads are turned by all this attention. They would be more than human if they didn't develop slightly inflated opinions of their own worth as a result. Neither do I criticize the tactics employed by industry to recruit these young men. Industry is simply adapting to the situation by using extreme techniques to cope with extreme circumstances. What I do deplore is the basic situation which creates these conditions.

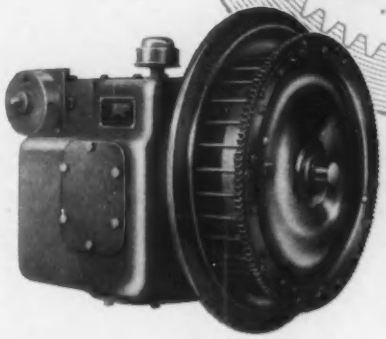
Students may be placed in three categories. The first group is composed of obviously superior engineers. Their scholastic records testify to their superiority. They are "dedicated" engineers in the true meaning of the word. Engineering is their life. They usually know exactly what kind of work they want to do and are quite aware that they are in a position to make specific or unusual demands. A wise recruiter makes concessions to their demands in the almost certain expectation that they will function best in the field of their own preference, and under any reasonable terms they impose.

Next is the group of highly capable engineers who are more responsible than anyone else for making the wheels go round. They are clearly equipped by temperament, native intelligence and devotion to engineering for engineering's sake to do outstand-

(Continued on page 408)

New PLAN-GEAR PGT TRANSMISSION

• PATENT PENDING •



the Transmission that's as simple to operate as an Electric Motor

• AMERICAN GEAR'S new **PGT** is a hydraulically operated, compound planetary transmission that provides a simple, versatile and extremely flexible means of power transmission.

• **PGT's** outstanding performance has been verified by complete tests in the laboratories of one of the country's leading Institutes of Technology.* It has been successfully used on earth movers, tractors, road rollers and similar equipment. Sturdily built, conservatively rated, **PGT** offers important advantages over more complex transmissions, including:

- Easily operated by anyone by merely moving a single hydraulic control lever
- Practically instantaneous (1.5 seconds) change of speed or direction without shifting gears
- Only one control valve lever for all speeds and neutral
- Utterly smooth...no shock...no jerk... no noise
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- Positive pressure-fed lubrication to bearings and gears
- Two power take-off apertures can transmit up to one-third of engine output maximum

*Complete report on request

Write today ***for this new 8-page booklet which gives complete information, design details on all 7 models of PGT transmissions***

• 7 DIFFERENT MODELS • 85 OR 150 TO 200 LB. FT. TORQUE
1 OR 2 SPEEDS FORWARD • CHOICE OF REVERSE RATIOS

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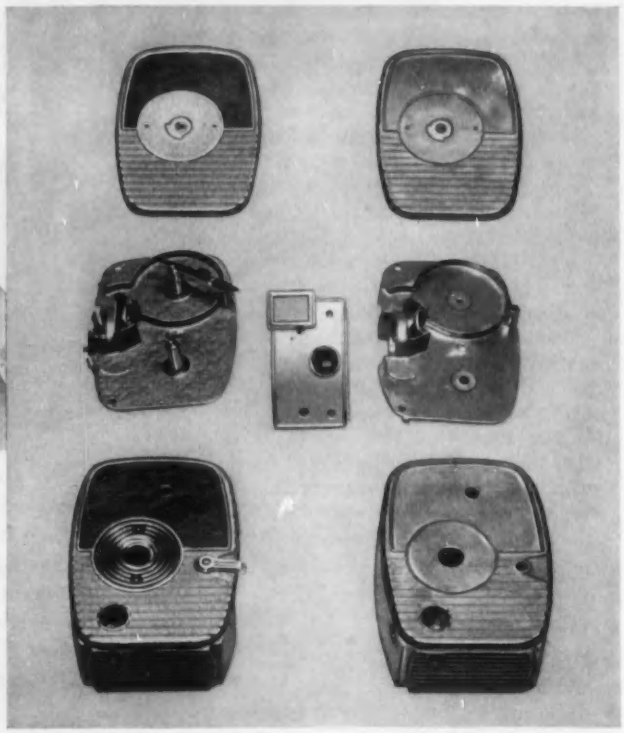
Subsidiary of BRAD FOOTE GEAR WORKS, INC., Cicero 50, Illinois

DIE CASTING REPORT

Contours, clever design and weight saving... attract light industry



The photographic industry, long a user of aluminum die-castings, is daily finding more ingenious ways of using this cost-and-weight saving process. Look at this Keystone 8 mm Capri movie camera. (1) A cast groove in the cover provides a positive light seal—almost impossible to achieve economically by other processes; (2) the mechanism plate features a cast film guide, a governor housing and cored holes which all simplify and speed assembly; (3) much machining is eliminated by cored holes and part has buffed finish for customer chrome plating, and (4) exceptionally smooth finish on case plus streamlined appearance and detail were possible only with die-castings.

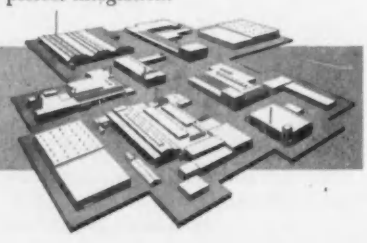
Clever engineering and major use of die-castings enable Keystone to produce a quality, precision camera at a price designed to attract volume sales.

Lawn Spray Nozzle Three core pulls, a 2 impression die, and a production of close to 300,000 zinc units per season. That's the story of this complicated little die-casting. Machining included punch press parting line, facing nozzle end and seat, reaming core flash at junction of two cores, facing hose connection, drilling one pin or shaft hole, and tapping hose thread and plunger cylinder end. All operations done by Precision. An example of perfect integration.

Write on your letterhead for a copy of "Die-Castings...Unlimited." Address: Precision Castings Co., Walnut St., Fayetteville, N. Y.

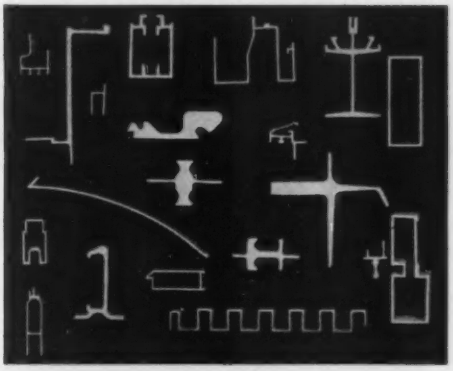
PRECISION CASTINGS CO.

A DIVISION OF **HARSCO Corporation**

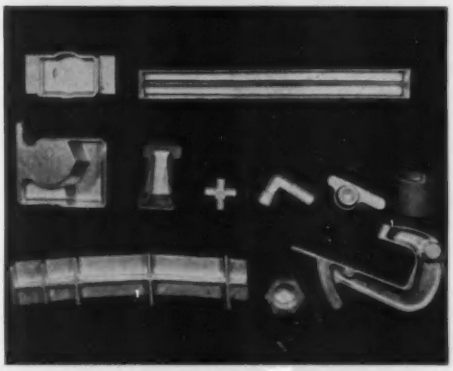


FAYETTEVILLE, N. Y.—SYRACUSE, N. Y.—CORTLAND, N. Y.—NEW YORK, N. Y.
CHICAGO, ILL.—CLEVELAND, OHIO—KALAMAZOO, MICH.

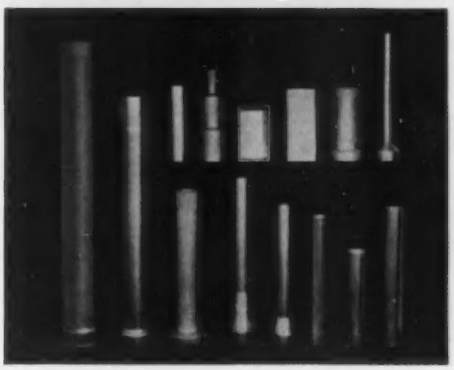
You can make it faster and better
with Harvey Aluminum



EXTRUSIONS . . . For decorative as well as basic parts, custom-designed aluminum extrusions replace riveted and welded assemblies . . . simultaneously adds strength, simplifies fabrication.

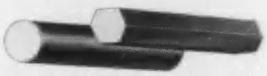


PRESS FORGINGS . . . Where parts must combine maximum strength with savings in weight, cost and manpower, Harvey aluminum forgings often completely solve the problems encountered by the designer.



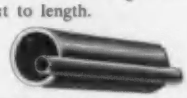
IMPACT EXTRUSIONS . . . Thin-walled, tubular structures can be produced by this method and held to very close tolerances. Machining is practically eliminated; scrap is greatly reduced.

STRUCTURALS . . . High strength, light weight, workability, corrosion resistance. Aluminum extrusions combine all four . . . are ideal as basic load-bearing members.



MACHINING STOCK . . . Harvey deep-drawn hex and round stock set a new mark in uniform grain structure—consistent from surface to core. This means fast, chatter-free cutting, long tool life, few rejects and true threads.

FORGING STOCK . . . If you make your own forgings in quantity, Harvey extruded forging stock can save many intermediate steps. Custom-designed extrusions whose cross sections approximate the forged blanks may be cut to length.



EXTRUDED PIPE AND TUBE . . . Seamless . . . uniform in structure, size and shape . . . clean and smooth inside and out . . . easily formed. Usable in applications ranging from portable irrigation systems to aircraft heat exchangers.

DRAWN TUBE . . . Combines strength and high finish . . . ideal for TV antennas, furniture, and similar products. Cold drawn for structural uniformity . . . and the temper is specially controlled for good workability.

SCREW MACHINE PRODUCTS . . . The West's largest installation of multiple-spindle screw machines can reduce your manufacturing costs. Harvey carries your job through from engineering to quality control.

Harvey is a leading independent producer of aluminum extrusions in all alloys and all sizes, special extrusions, press forgings, hollow sections, structurals, rod and bar, forging stock, pipe, tube, impact extrusions, aluminum screw machine products and related products. Also similar products in alloy steel and titanium on application.

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Continuous Automatic BATCH COUNTING

Instantaneous Reset

Counts batches continuously without slow down and without missing a single count between batches.

Automatic Batch Control

Operates automatically to close chutes, operate diverter, start or stop conveyor, machine, etc.

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May be located remote from the source of actuation (switch, relay, photoelectric unit or other circuit breaking device).

Models to fit the job

Full range selection; permits quick setting for any batch quantity within the range of the counter (ranges to 10,000).

Limited selection; permits quick setting to certain batch quantities for which the counter is built.

Wide Choice of Features

Warning or preliminary control, built-in totalizing counters, remote starting and stopping, and many others.

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with application case histories or tell us about your requirements.

PIC PRODUCTION INSTRUMENT CO

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ing work. They are well-rounded and versatile—capable of stepping into many different kinds of assignments. Signing them up is a recruiter's delight, even the interviews are pleasant.

Finally, there is a group which falls below the high level of the other two. A great many of these are conscientious, qualified engineers who, for a number of valid reasons, were unable to distinguish themselves scholastically. But a goodly percentage of this group is made up of young men who either do not have the natural aptitudes for an engineering career, or have been attracted to engineering solely because of the good employment possibilities.

A good many competent authorities feel that the educational institutions are not capable of turning out well-rounded engineers. The principal complaint is that engineers study only engineering topics, to the exclusion of everything else. These critics maintain that engineering graduates are incomplete, inadequate for their jobs, without a generous dosage of the fine or liberal arts.

With a few exceptions, I think today's graduates are of exceptionally high professional standards. Their excellence is a tribute to the nation's colleges. These colleges are accomplishing this by concentrating on instilling the technical skills in engineering graduates.

However, I do have a couple of minor objections. For one thing, I believe engineers should be more articulate. As in every other profession, engineers must be skilled in the arts of persuasion and clarity of presentation.

I have no quarrel with those who maintain that an engineering education alone is not sufficient training for the top engineering jobs or the higher functions of management. But I do believe in the old adage, "First things first." That is why I contend that the college phase of an engineer's training should emphasize engineering subjects.

It is within industry that the engineer enters phase two of his education. Here he acquires—to a degree commensurate with his aptitudes and receptivity—other attributes of a well-educated individual. Among them are an ability to get along with people; a knowledge of how to apply his

(Continued on page 412)

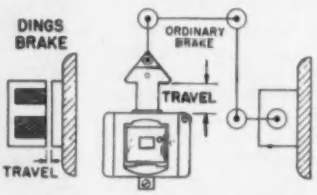
DINGS BRAKE BRIEFS

THRU-SHAFT DESIGN SOLVES INSTALLATION PROBLEMS

Simple modification of the cover converts Dings Magnetic Disc Brakes for thru-shaft installation. This facilitates direct coupling or the use of hand cranks, electrical tachometers, pulleys, plugging switches, etc. Dings Brakes accommodate standard NEMA shaft extensions, and are designed to meet new re-rated and old NEMA motor standards. They easily mount on all NEMA "C" flange motors and are interchangeable with any "C" flange mounting disc brake.

FULL DIRECT ACTION

Direct acting magnets eliminate all mechanical linkages and levers. Movement of the braking assembly is measured in thousandths of an inch,



assuring instantaneous release and consistent, positive stops. All wear is confined to the friction linings.

ADDITIONAL ADVANTAGES

Dings Magnetic Disc Brakes offer a combination of outstanding features for any industry which requires automatic, controlled, *all-ways* dependable braking.

1. Wide torque range—1½ to 175 lbs. ft.—easy torque adjustment.
2. Fail-safe design in event of power failure.
3. Simple design and rugged, compact construction.
4. Standard drip-proof or dust-tight waterproof enclosures.
5. Floor or motor mounting, horizontal or vertical operation.

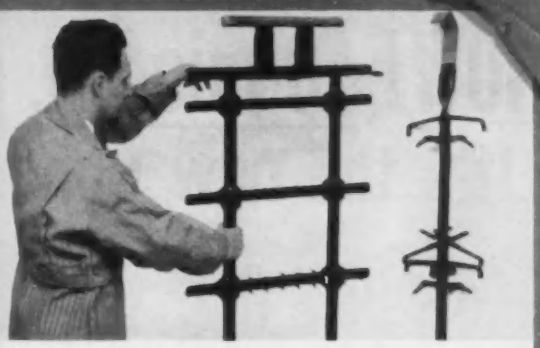
Specify Dings Magnetic Brakes from your regular motor supplier. While these units are easy to select and apply, it will pay you to take advantage of Dings complete engineering service to help solve specific brake problems. Write for Bulletin BK4003.

DINGS BRAKES, INC.
A SUBSIDIARY OF DINGS MAGNETIC SEPARATOR CO.
4715 West Electric Avenue
Milwaukee 46, Wisconsin

See our catalog in SWEETS PRODUCT DESIGN FILE section 5a/Di

D8256½

Slip-proof grip for work gloves is provided by dots of plastisol applied by high-speed printing. Flexibility and feel are unaffected; wearing quality greatly improved. Hobnob* gloves manufactured by **Wells-Lamont Corp.**, Chicago, Ill.
*T. M. Registered by Wells-Lamont Corp.



These plating racks enjoy longer life because of the chemical and heat resistance of the plastisol coating. In addition, the smoother finish permits rapid draining, reduces contamination of subsequent baths. Manufactured by **Imperial Rack Co., Inc.**, Flint, Mich.

This motor coil lasts longer because it is insulated with a tough, abrasion-resistant plastisol. The fast, economical application in this case was by dip coating, followed by a short bake at moderate temperatures.

"Chem-o-sol" plastisol compounds used for the products shown are formulated by **Chemical Products Corporation**, East Providence, R. I.

Liquid plastisols provide

Different ways to improve products

Each of these three products does a new job, or a better job, because of liquid plastisols based on BAKELITE Brand Vinyl Dispersion Resins.

Plastisols are easily used. Dipping and molding are the techniques generally used. They are rapidly cured to their finished state . . . resilient, pliable and tough . . . and stay that way. They have good electrical properties. A wide range of brilliant colors with a variety of surfaces is available from pastisol formulators.

Complete information may well give you profitable ideas on how to improve your products with plastisols. Write today to Department PM-145.

BAKELITE BRAND RESINS

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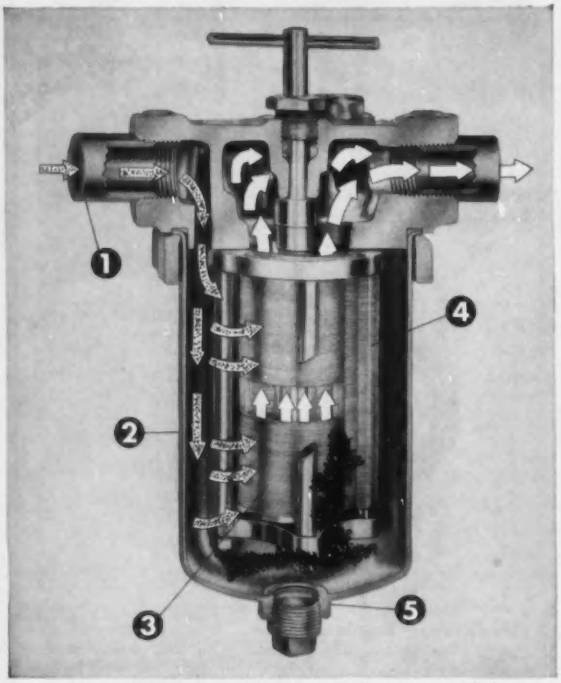
NOW! 40-micron, self-cleaning filter
It's the new Cuno SUPER Auto-Klean



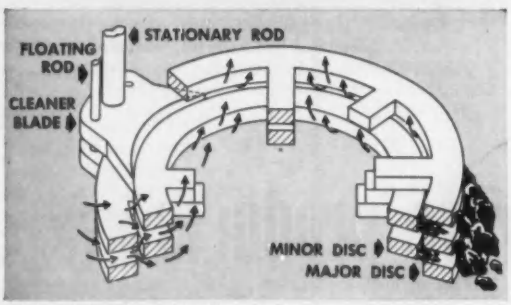
HOW IT WORKS. Dirty oil enters inlet (1) at left, fills housing (2) and flows through metal edge-type filter (3). Clean oil rises through center of filter, leaves at right. Dirt combed out by cleaner blades (4) is removed through drain (5).

Cuno's new SUPER Auto-Klean is the first practical, compact micronic filter for lubricating oil, hydraulic fluid, coolant, fuel, and other industrial fluids.

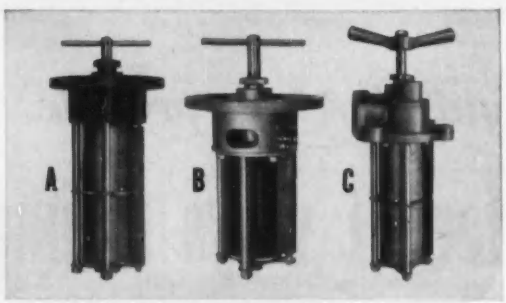
Many times smaller than other micronic filters of equal capacity, Cuno's new SUPER Auto-Klean filter now makes possible economical, micronic filtration at high flow rates and eliminates the need for replacement cartridges in most cases. Here's what it offers:

1. **Full-flow** 40-micron filtration with a self-cleaning filter. Positive protection against particles larger than 40 microns (actually 0.0015 in.). All-metal filter can't rupture or channel.
2. **Easy cleaning.** Just turn the handle—by hand or continuously with motor drive. No interruptions for cleaning.
3. **No cartridge changes.** Ends operating costs if you've been using cartridge filters.
4. **Low pressure drop, no pressure drop build-up.** An 8" by 2¾" SUPER Auto-Klean filters 30 gpm of 200 SSU oil with only 3 psi pressure drop—up to 75% more with slightly higher pressure.
5. **High capacity in a small package.** Many times smaller than replaceable-cartridge type filters of equal capacity, it saves with lower initial costs, lower installation costs.
6. **Easy to build into new equipment.** Available for line-type housings *(left)* or incorporation in sump or reservoir *(below.)* Works in any position.
7. **Easy to install in old equipment.** Fits existing Auto-Klean housings. You can easily replace most 2¾" diameter elements with SUPER Auto-Klean for finer filtration.

Write today for complete technical data on the new SUPER Auto-Klean for your new or existing equipment. Ask for Catalog No. SAK-057. Cuno Engineering Corporation, 20-4 South Vine Street, Meriden, Connecticut. 59



FILTER ELEMENT consists of stacked major and minor discs and cleaner blade bearing against minor discs. Small arrows show flow. Short restrictions between minor and major discs stop 40-micron particles but allow high flow rate.



FILTERS FOR INTERNAL PIPING *(A and B above)* allow streamlined design plus the best infiltration. Flange mounting with external outlet *(C above)* and line-type *(large cutaway above left)* are just a few of many other possibilities.

CUNO ENGINEERED FILTRATION

See this and other Cuno filters at Booth No. 403, Design Engineering Show, Philadelphia—May 14-17

AUTO-KLEAN (edge-type) • MICRO-KLEAN (fibre cartridge) • FLO-KLEAN (wire-wound) • PORO-KLEAN (porous metal)

TO THE MEN WHO DESIGN AND BUILD BETTER PRODUCTS...

Heres How JOHN CRANE CAN HELP YOU!

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"John Crane" Chemlon offers the remarkable properties of DuPont Teflon in basic forms and parts of all types for practically all applications. These range from basic forms, such as sheet, rod, tubing and tape, to machined, molded or extruded parts fabricated to specification.

Use "John Crane" Chemlon Products for: handling all difficult acids, corrosives and solvents at temperatures from −120°F. to +500°F. . . . electronic insulation where high dielectric strength, high arc resistance and low power factor are vital . . . non-stick applications.

MECHANICAL PACKINGS

"John Crane" maintains nationwide service and engineering to supply mechanical packings for every industrial requirement. Packings are available in all sizes, styles and materials to suit individual requirements and conditions.

Use "John Crane" Packings for: handling all types of liquids and vapors from water and steam to the most destructive acids, alkalis and solvents . . . temperatures to 1200°F. and over . . . to meet your pressure requirements.

MECHANICAL SEALS

"John Crane" engineers seals of all types and sizes for every application. Construction features include positive drive, self-alignment to compensate for normal shaft run out and precision lapped sealing faces.

Use "John Crane" Seals for: all types of rotating shaft applications such as water, steam, boiler feed water, petroleum products and hot oil, acids, corrosives and solvents . . . over a wide temperature and pressure range.

LAPMASTER Lapping Machines

Here's a machine capable of generating surface flatness to less than one light band—finishes to 2 RMS consistantly in short or high production runs . . . a machine that has given many designers an opportunity to obtain product improvement and performance at lower cost.

Use the "John Crane" Lapmaster for: precision lapping of parts for adding machines, engines, transmissions, cameras and projectors, tool and die equipment, quartz crystals, etc. . . . materials such as monel, steel, stellite, brass, aluminum, glass, carbon, plastics and ceramics.

PLASTIC LEAD SEAL* AND THRED-GARD

"John Crane"* PLS easy-to-apply plastic sealing compound provides positive protection against leakers under service applications up to 550°F., 6000 psi. It lasts for the life of the connection, yet permits easy disassembly at any time because it never hardens.

Use "John Crane" PLS for: handling water, steam, gas, petroleum products, chemicals and refrigerants...on pipe joints, threaded connections, plugs, screwed fittings, flanges and gaskets.

"John Crane" Thred-Gard high temperature compound lubricates and prevents seizing and galling of threaded surfaces and fittings under extreme heat conditions up to 1200°F. It permits connections to be drawn to a greater degree of tightness without undue strain.

Use "John Crane" Thred-Gard for: preventing damage to studs on exhaust manifolds, cylinder heads, heat exchangers, coolers, condensers . . . flange bolts on pumps, valves, autoclaves, reactors, kettles . . . die casting dies and die casting machine fittings.

GET FULL DETAILS on how John Crane can help you. Check the information you want, fill out and mail in this coupon.

- ☐ John Crane Teflon Products
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Crane Packing Company, 6445 Oakton St., Morton Grove, Ill., (Chicago Suburb). *In Canada: Crane Packing Co., Ltd., Hamilton, Ont.*

JOHN CRANE **CRANE PACKING COMPANY** 38 YEARS INDUSTRIAL PROGRESS

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BEDEVIL COMPETITION . . . You'll show them no mercy when you use some of the profitable, new ideas, developments, applications you see at the NATIONAL PLASTICS EXPOSITION. It's at New York's new Coliseum, June 11-15. Write for your tickets, now. But since there are no general public admissions, please make requests on business letterhead.

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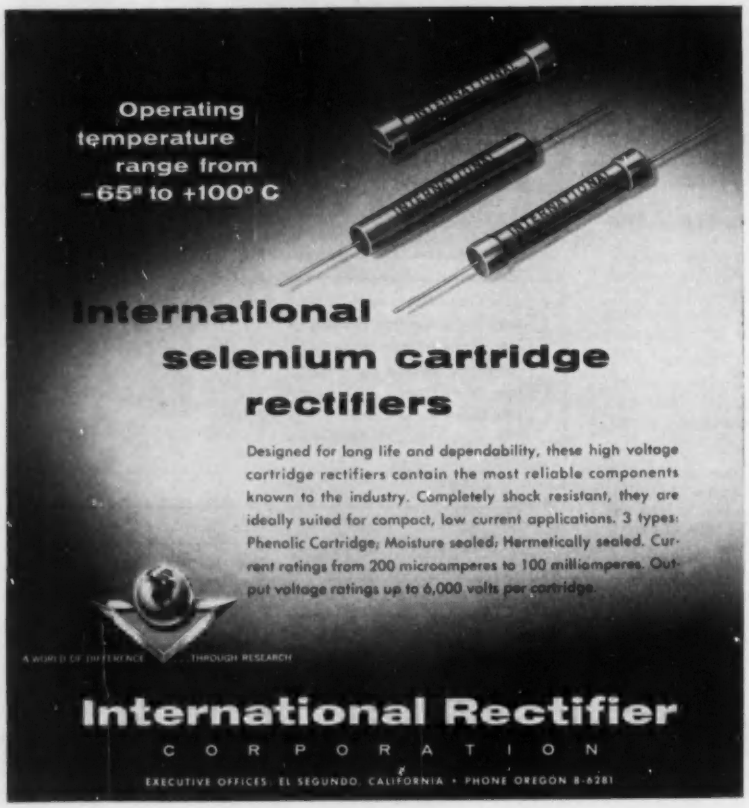
Operating temperature range from -65° to +100° C
International selenium cartridge rectifiers
Designed for long life and dependability, these high voltage cartridge rectifiers contain the most reliable components known to the industry. Completely shock resistant, they are ideally suited for compact, low current applications. 3 types: Phenolic Cartridge; Moisture sealed; Hermetically sealed. Current ratings from 200 microamperes to 100 milliamperes. Output voltage ratings up to 6,000 volts per cartridge.
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technical knowledge to specific projects; a familiarity with the latest techniques and processes being developed by a dynamic, fast-moving American industry; and the development of qualities of leadership and creative inventiveness. How well he becomes a part of the whole—without sacrificing his individuality or independence of thought—and how much he learns are largely a measure of the individual's worth.

The present shortage is critical, but rays of sunlight are breaking through the gloom. Industry has demonstrated considerable ingenuity in coping with the problem of too few engineers, and in sponsoring self-improvement programs to make maximum use of those available.

The crux of the problem, however, has not yet been approached. If we are to remedy this problem for the years ahead, we must formulate procedures that will assure industry of an accelerated flow of engineers who are in engineering for engineering's sake.

The only way to accomplish this is by telling the youth of America what a satisfying and rewarding profession engineering is, and by correcting one of the most glaring deficiencies in our educational system—inadequate opportunities for scientific training in preparatory schools.

Editor's Note—See also March 1955 issue, page 135.

Servo Pump vs Servo Valve Controls

Abstracted from "Servo Pump vs Servo Valve Controls," by L. D. Taylor, Staff Engineer, Vickers Inc., Detroit, Mich.; presented at Vickers Turbojet Engine Hydraulics Symposium, Feb. 2 and 3, 1956, Detroit, Mich.

The title "servo pump" is here applied to a control circuit with a variable displacement pump in which the amount of power required to vary the rate and direction of pump flow is relatively small compared to the pump's power capabilities. The force to move the controlling yoke is provided by a stroking piston which is in turn controlled by the use of a metering valve. The metering valve is controlled by mechanical linkage or electro mechanical transducer. Auxiliary pumps may be used to supply the

(Continued on page 414)

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control pressure and for replenishing and supercharging oil.

A servo pump as defined here is a flow generator, and pressure is the result of application of load to the load actuators. Rate of actuator movement is, therefore, independent of load.

A servo pump meters or controls the signed to deliver maximum force at any load velocity. This is possible because there are no main line restrictions other than the lines themselves.

A servo valve meters or controls the amount of oil flowing to a load by varying a restriction in a hydraulic supply line leading to the load. Control of this valve may be mechanical or an electro-mechanical transducer.

Most common fluid source is a pressure-controlled variable pump. Accumulators may be required when load acceleration must be greater than pump response time.

Because flow through the servo valve is proportional to the area of the valve opening and the square root of pressure drop across the valve, gain or flow sensitivity is dependent on load reaction.

The available force at the load piston is not only a function of supply pressure but of load velocity as well. Maximum horsepower is delivered to the load (at full valve opening) when one-third of the available pressure drop is across the valve. However, losses are not necessarily excessive since operation is usually at zero or very low flows through the valve.

Servo valves have high response speeds since they may be placed close to the load and the valve itself is simple, having small mass.

How to Improve Profits—A Challenge to Engineering

Abstracted from article of same title by Kenneth L. Block, Management Consultant, A. T. Kearney & Co., Chicago, Ill.; *Mechanical Engineering*, Feb. 1956

Some good rules to follow in designing for low cost are as follows:

1. Design for maximum simplicity of all functional characteristics and sturdiness required in the end product.

2. Ask yourself, "Is it absolutely required?" If possible, eliminate the part or consolidate it with others.

3. Design for most economical pro-

(Continued on page 418)

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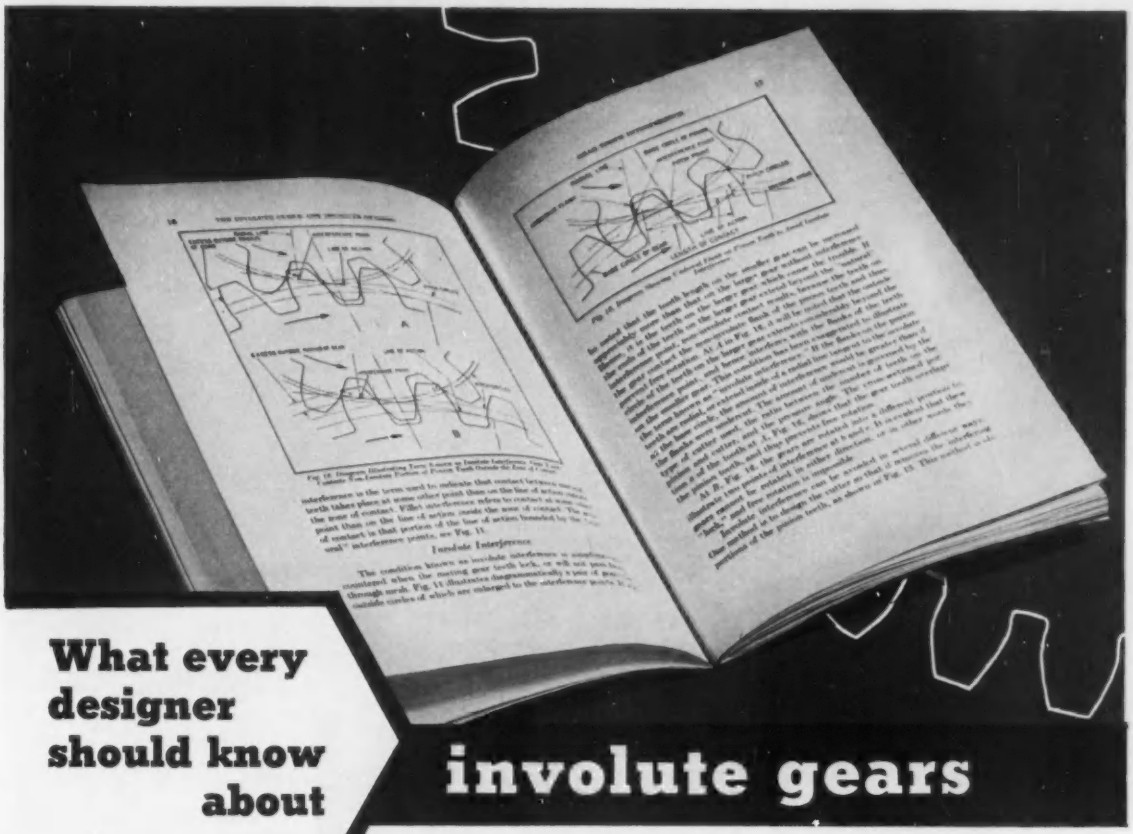

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The properties of the involute curve as a gear-tooth profile offer many possibilities in the design of gears. To take full advantage of them, you must know the three basic elements of gear design and the fundamental laws of the involute curve.

These are stated in "The Involute Curve and Involute Gearing," a complete treatise on Involute Gear Design. The contents of this booklet also include such useful subjects as the function of gearing, the application of the involute to gear teeth, the Gear Shaper Cutter, generating involute gears on the Fellows Gear Shaper, checking profiles on Fellows Involute Measuring Instruments and definitions of gear tooth elements. A copy is yours for the asking. Just write any Fellows Office.

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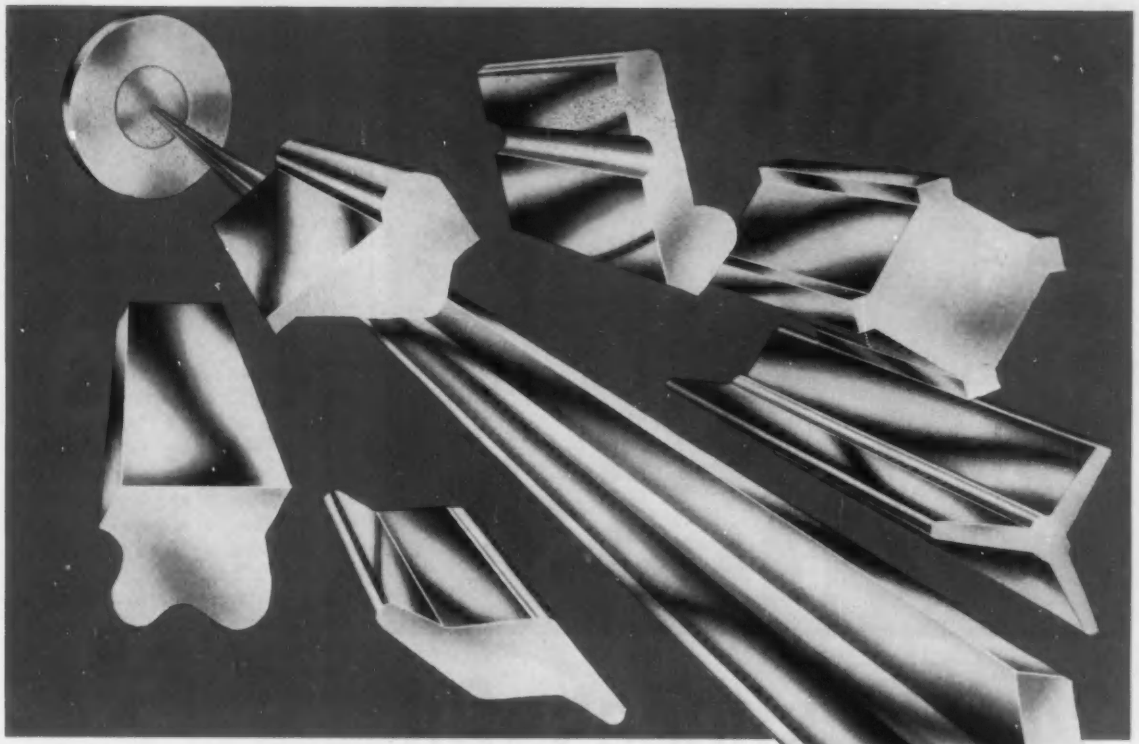

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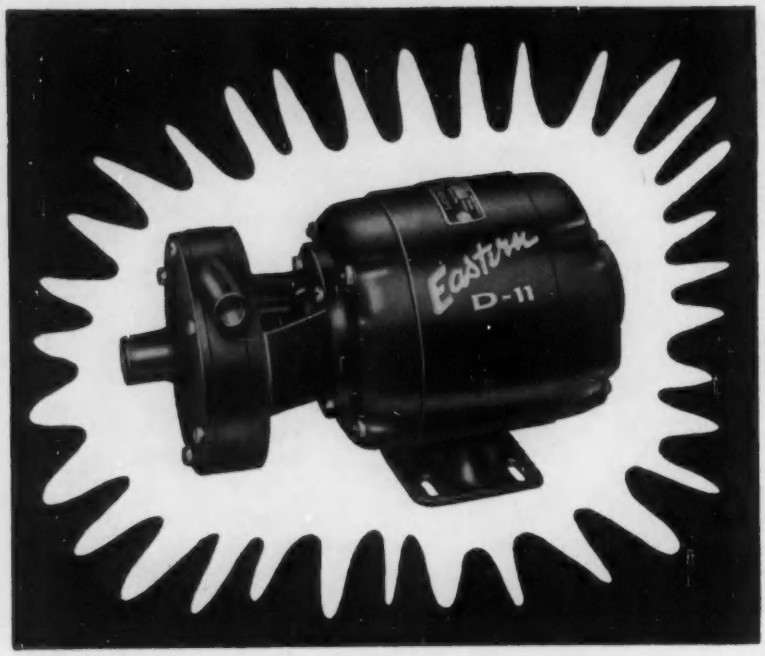

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4. Select the lowest-cost material which will fit the foregoing requirements.

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Standardization of parts can reduce costs in other departments. Some companies set up a "standard-parts book" in which they list permanent part numbers of commonly used parts, such as hardware and fittings. Management approval is required for design and use of any hardware or fittings not listed in this book.

The intelligent use of engineering tolerances can decrease the cost of a part and minimize scrap.

The statistical quality-control department is often of great help where close tolerances lead to excess cost and result in excess scrap.

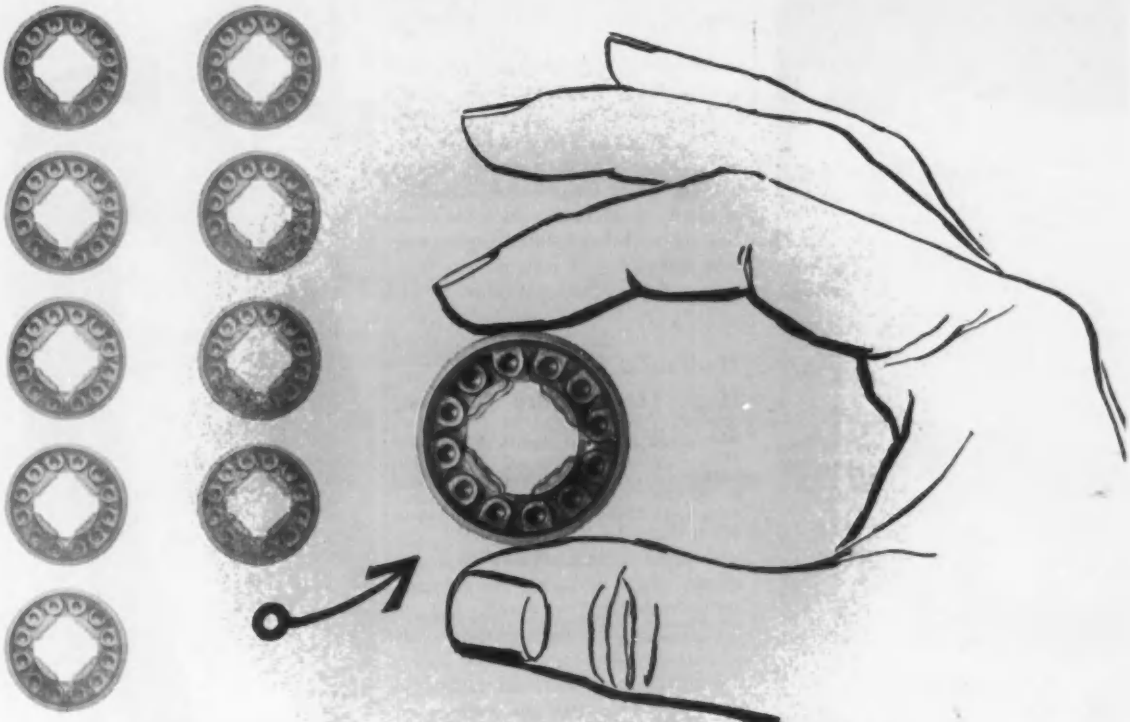
Engineering change orders often increase the costs in other departments needlessly. Changes should be put into effect only if the over-all cost and savings picture is favorable, of if they affect safety or the reputation of the company.

There are many ways in which the engineering department can reduce costs through proper organization and administration of its own department. Reduction in cost can often result from proper utilization of technically qualified design engineers on design work and less technically trained people for service work.

One of the best ways to determine the engineering cost of any project is to use a time-charge system which will allocate every hour of each engineer's time to a proper breakdown within each project. These hours, multiplied by the engineering cost per hour of the engineer's time plus engineering overhead allocated to those hours, give an accurate breakdown of the total cost of the job or the cost of any part of the job. (**Editor's Note.** See also "Control of Cost of Development," 1955 Annual Handbook, page A9.)

Several types of standards can contribute to efficient operation of the engineering department: An engineering-procedures manual, a drafting-

(Continued on page 420)



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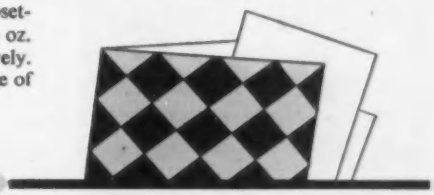

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room manual, a design handbook, and a standards-parts book.

Engineering drawings can be simplified by eliminating nonessentials, simplifying delineation, and stripping all frills which do not result in a loss of clarity or accuracy. In some cases this approach has reduced engineering time from 20 to 30 per cent.

Hydraulic Fluids for High Temperature Systems

Abstracted from "Hydraulic Fluids for High Temperature Systems" by Bernard Rubin and Lt. Harry Schiefer; presented at Vickers Turbojet Engine Hydraulics Symposium, Feb. 2 and 3, 1956, Detroit, Mich.

This paper is intended as a discussion of the effects of higher temperatures on hydraulic fluids in current and potential use by the military service. The aircraft industry and military service groups associated with and responsible for hydraulic system and component design have in the last two years formalized requirements in a series of types:

Type I	−65 F to 160 F
Type II	−65 F to 275 F
Type III	−65 F to 400 F
Type IV	0 F to 550 F
Type V	0 F to 700 F

Of these types, only the first two have been in service, consequently data on the performance of MIL-0-5606 hydraulic fluid is far more complete than on other higher temperature fluids. Fluids for the Type III system, the silicate esters, are reviewed from a background of laboratory and mock-up experience. Laboratory studies have been performed to 700 F on some fluids, and a few experiments cover the use of these fluids in components.

Experience has shown that for use in the 200 F to 275 F range, the properties of residual film formation, vapor pressure and inflammability which are affected by volatility are the most important for systems application.

If systems are closed and pressurized so that evaporation is minimized, film tackiness need not arise. Vapor pressure-temperature data are included for MIL-0-5606 which indicate the degree of pressurization required in a closed system above 200 F. The flash

(Continued on page 424)

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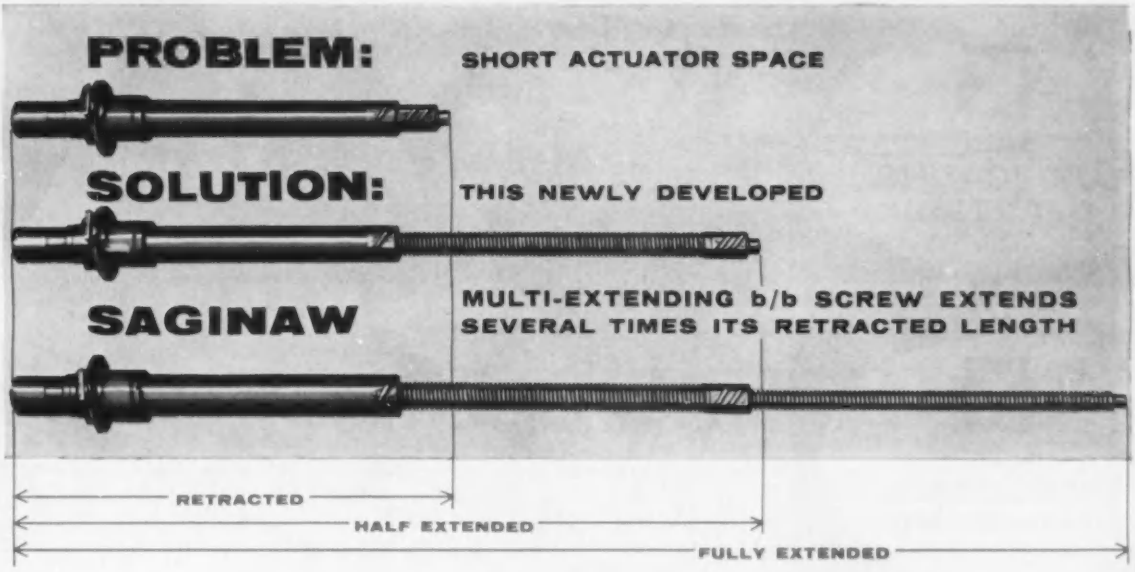

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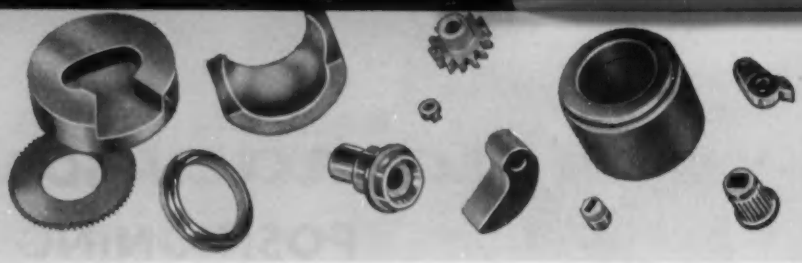

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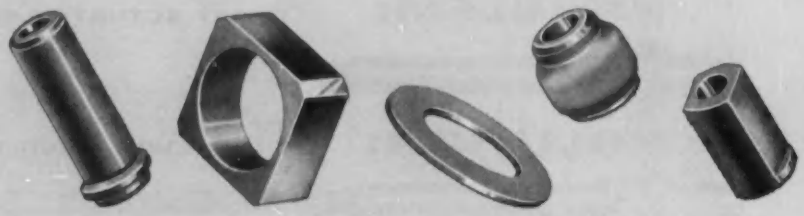
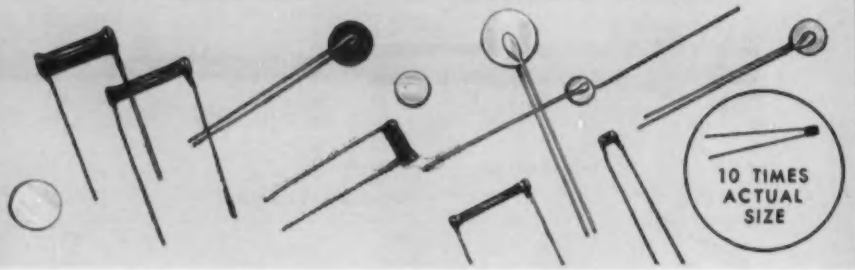


NTC RESISTORS (THERMISTORS)



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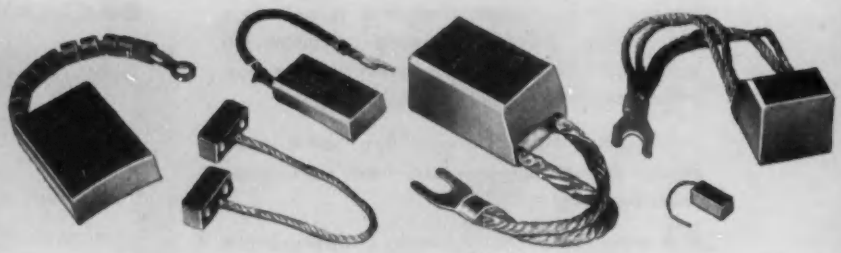

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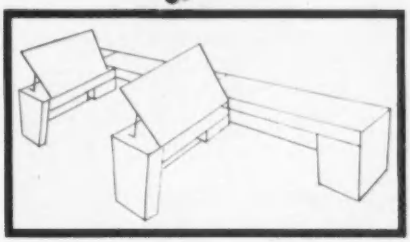

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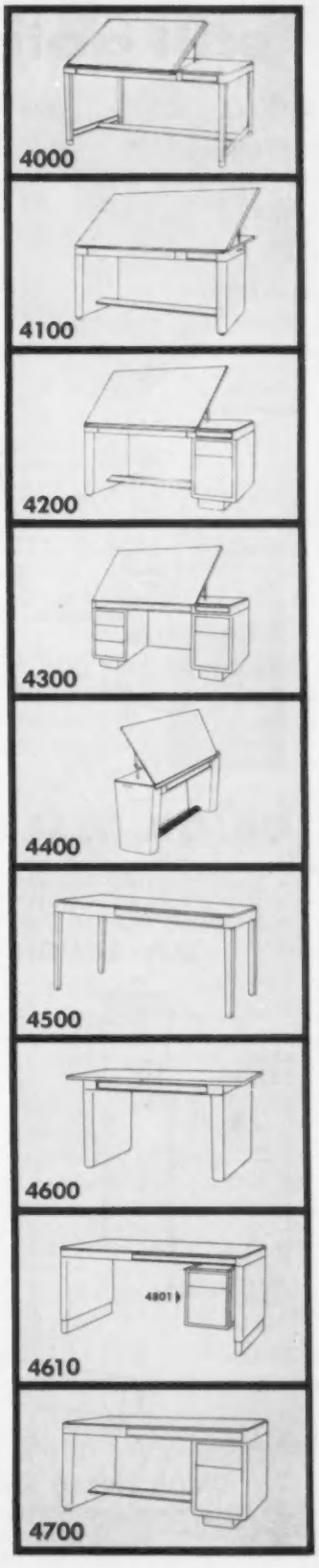

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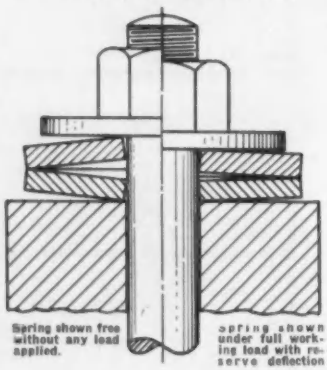
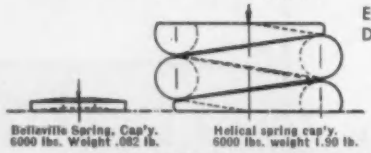


Spring shown free without any load applied.

Spring shown under full working load with reserve deflection



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point of this fluid is about 230 F and spontaneous ignition temperature is 400 F.

Pumping tests indicate the viscosity is adequate to lubricate piston pumps at 300 F and probably up to 400 F. Thermal stability is excellent to 450 F.

Recently a specification has been released which covers the requirements for a —65 F to 400 F fluid and is designated as MIL-H-8446 (USAF). Some of the silicate esters show promise for this application. Certain design aspects have to be followed with the use of these fluids and precautionary measures have to be taken in their handling. Lubricity is apt to be somewhat lower than presently attained with MIL-0-5606 at its present operating temperature of 160 F.

In the Type III range most research and development effort is being concentrated on the silicones, chlorinated silicones, hydrocarbon and mineral oils and chlorinated biphenyls.

Editor's Note—See "Synthetic Hydraulic Fluids," Dec. 1954 page 163.

General Properties of the New Super-Polyethylenes

Abstracted from "General Properties of the New Super-Polythylenes," by G. H. Sollenberger, Koppers Co., Inc.; *Technical Papers, Vol. II,* 12th Annual National Technical Conference, Society of Plastics Engineers, Cleveland, Ohio, January 1956.

Comparable parts of conventional and "super" polyethylene were subjected to 250 F. In this test, the conventional polyethylene part completely loses its shape, while the article molded of super-polyethylene retains its shape and surface finish, showing about 2 to 4 per cent dimensional reduction. Exposure for a much longer period at 212 F will generally show the same 2 to 4 per cent change.

Preliminary work indicates that the super-polyethylenes also respond to irradiation, and that a comparable improvement of properties can be obtained with about 25 per cent the megarep input required for conventional polyethylene.

Another excellent example of the broad range of properties embodied in the super-polyethylenes is their toughness at low temperatures. On the Izod impact tester, un-notched samples showing over 32-ft-lb per inch of face

(Continued on page 428)

ONE GOOD DESIGN DESERVES ANOTHER

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VALCOR Solenoid Valves are engineered for use in food vending machines, machine tools, chemical, food and drug processing industries, oil burners, air-conditioning, laundry machinery, air and hydraulic cylinders and other general industrial and fluid power applications.

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Elec.: 115V-60 cy., 10 watts
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For use with water, oil, air and gases.
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Max. Pressure: 125 lbs.
Normally Closed or Normally Open

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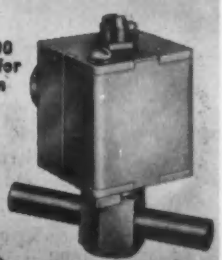

2 Way—Designed to take full back pressure.
Max. Pressure: 350 lbs.
This valve is manufactured in accordance with standard refrigeration specifications. Quotations on request.

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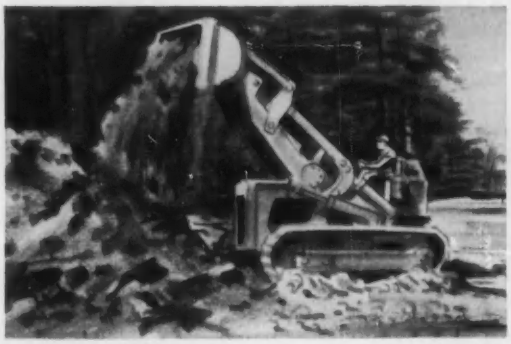
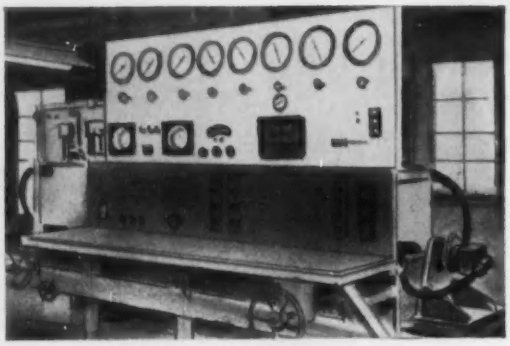
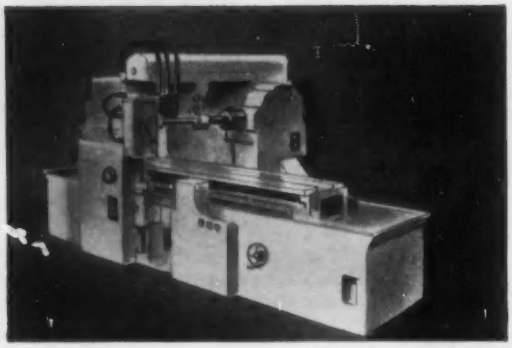
How hydraulic systems are simplified with 2000 psi vane pumps



Lower weight on mobile equipment with smaller size lines, smaller controls.



Lower cost for test stands which require pressures up to 2000 psi.



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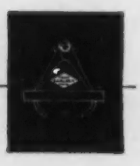

Packings, Gaskets, Oil Seals, Mechanical Seals, Rubber Expansion Joints

at room temperature still show over 32 ft-lb in dry ice—(−100 F).

In the case of notched samples, the dry ice impact strength was over 60 per cent of the room temperature strength. The value of this retention of properties at low temperatures is readily apparent so far as aircraft, military, and refrigeration and wire coating applications are concerned.

Short-term hydrostatic tests on 1 in. IPS Schedule 40 pipe show a burst strength for conventional polyethylene of 300-400 psi as opposed to 900-1000 psi for the super-polyethylene type. It has also been found that the strength of the super-polyethylene pipe does not fall off rapidly as the temperature increases. Tests in boiling water show that super-polyethylene pipe has about the same bursting strength at 212 F that conventional polyethylene pipe displays at room temperature. Long-term service tests at various pressures and temperatures are under way.

Rather surprising tensile strength has been observed in monofilaments of super-polyethylene, with readings as high as 95,000 psi. This figure is considerably above the strength of vinylidene chlorides, and equals the strength of nylon monofilaments of the same diameter.

Since these new high modulus materials are ethylene polymers, their chemical resistance is generally comparable to that of conventional polyethylenes with respect to aqueous solutions of acids, alkalis, and salts. Resistance to detergents is very good, as is illustrated by the proposed standard test for environmental cracking. Long-term chemical tests are under way.

The flexibility of conventional polyethylene, while quite desirable for squeeze bottles and similar applications, can be a serious limitation for many other jobs. For years the plastics industry has wanted a material with the chemical inertness and toughness of polyethylene coupled with semi-rigidity. The super-polyethylenes appear to fill the bill.

This means, however, that pipe will probably be shipped in 20 ft lengths instead of being coiled. It means basins and bowls which do not distort when filled and containers that hold their shape. It may also mean film which can be pushed through auto-

(Continued on page 433)

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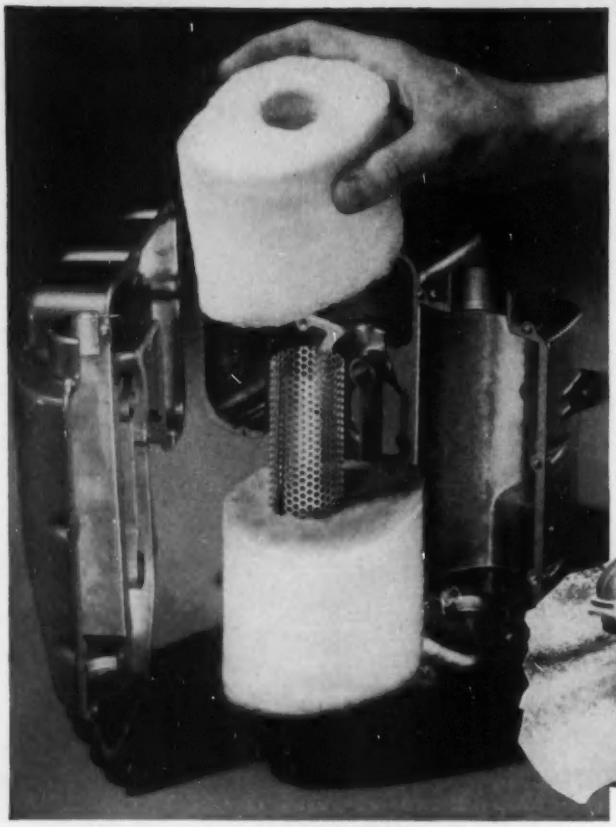
INSULATION news from L·O·F GLASS FIBERS COMPANY



S-h-h-h!

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Evinrude chose Microlite insulation for three reasons:

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- low density
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- low space requirement
- easy handling
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- resistance to moisture and settling

For more information on design possibilities of L·O·F Glass Fibers' insulation, contact our nearest office; or write: *L·O·F Glass Fibers Company, Dept. 4-56. 1810 Madison Ave., Toledo 1, Ohio.*

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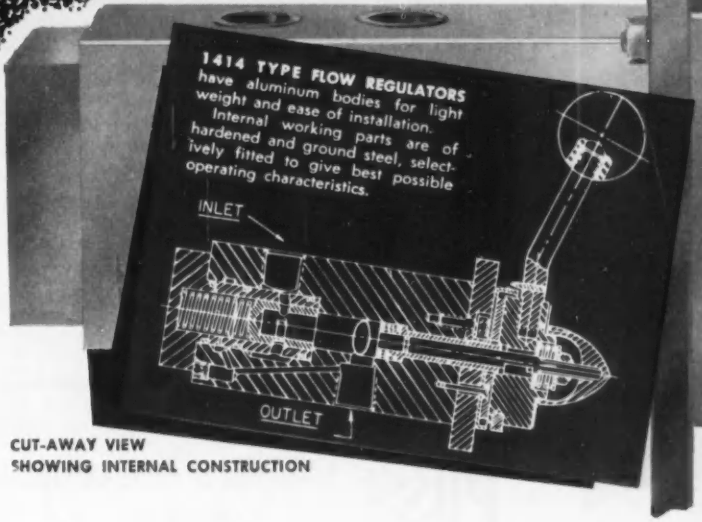
1414 TYPE FLOW REGULATORS have aluminum bodies for light weight and ease of installation. Internal working parts are of hardened and ground steel, selectively fitted to give best possible operating characteristics.
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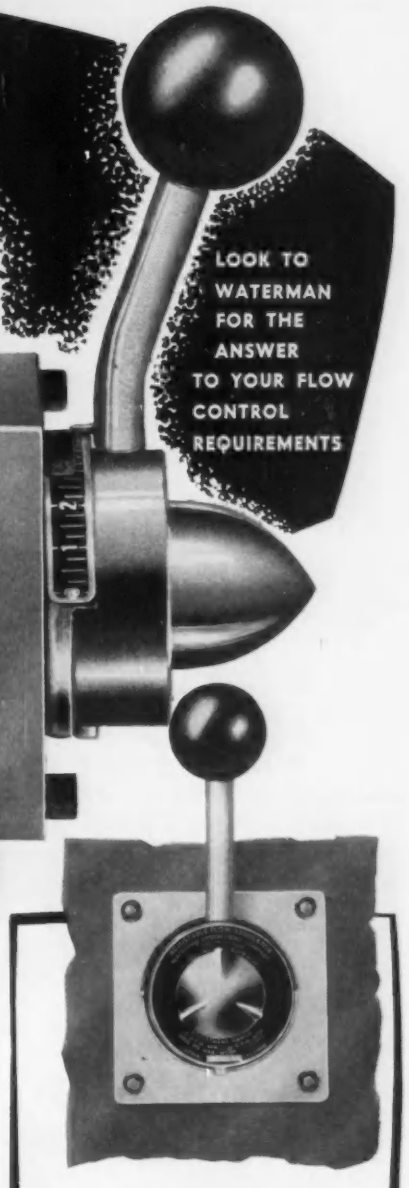

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Increases the flexibility of your hydraulic system . . . ideal for installations requiring frequent changes in operating speeds.

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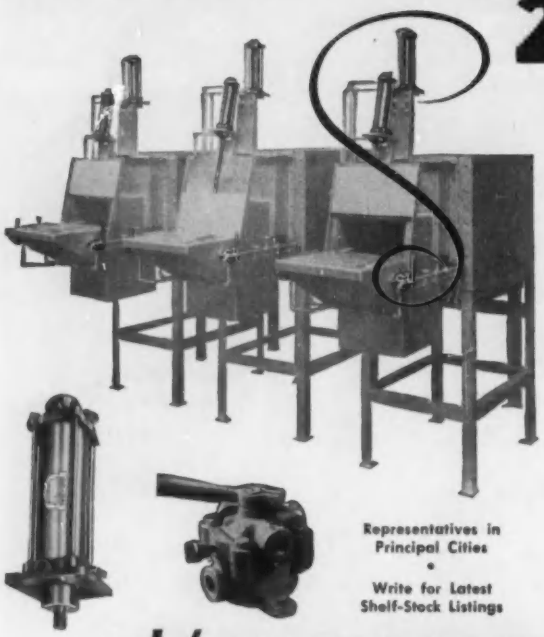

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Another reason why Hevi Duty specifies NOPAK Products is the simplicity and ease of their installation . . . an important factor in cutting assembly costs.

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matic packaging machines like paper or cellophane instead of being pulled through. This higher stiffness modulus may not influence the use of super-polyethylenes in wire coatings, since the stiffness of the conductor will probably be the controlling factor.

The polymerization process, with its many modifications, is sufficiently flexible that it is possible to produce a variety of polymers which display a wide range of physical properties.

Examples are two materials which this company is currently offering. These first two types have been selected as having physical properties which appear to be well adapted to specific applications in the plastics industry. Type 6200, with a melt index of 1.0-3.0 and a tensile strength of 2800-3800 psi, is recommended for general injection molding work, where easy flow and excellent surface appearance is desired. Type 6600, with a melt index of 0.1-1.0 and a tensile strength of 3800-5000 psi, is suggested for jobs which require good mechanical properties but do not demand best appearance. We expect that other types, embodying different properties will be offered as our developments progress.

For years, the buyer of injection-molded plastic articles has had to be content with the dull, lusterless waxy surface of articles molded from conventional polyethylene. Now articles molded from "Super Dylan" polyethylene type 6200 can have a beautiful smooth glossy appearance. If the injection molder should require the higher mechanical strength of type 6600, he must today accept a less attractive surface finish. This condition, it is hoped is temporary and it is believed that good surface quality should be possible over the entire range.

Water-quenched film has a smooth, brilliant finish and, incidentally, is completely non-blocking.

While the super-polyethylenes are quite transparent in thin sections, such as packaging film, the natural color in greater thicknesses is a translucent white. Starting with such a material, a wide range of translucent and opaque colors is possible, depending on the thickness and colorant concentration. For outdoor usage, black is recommended.

Editor's Note. Watch for 16-page summary of plastics development in June.

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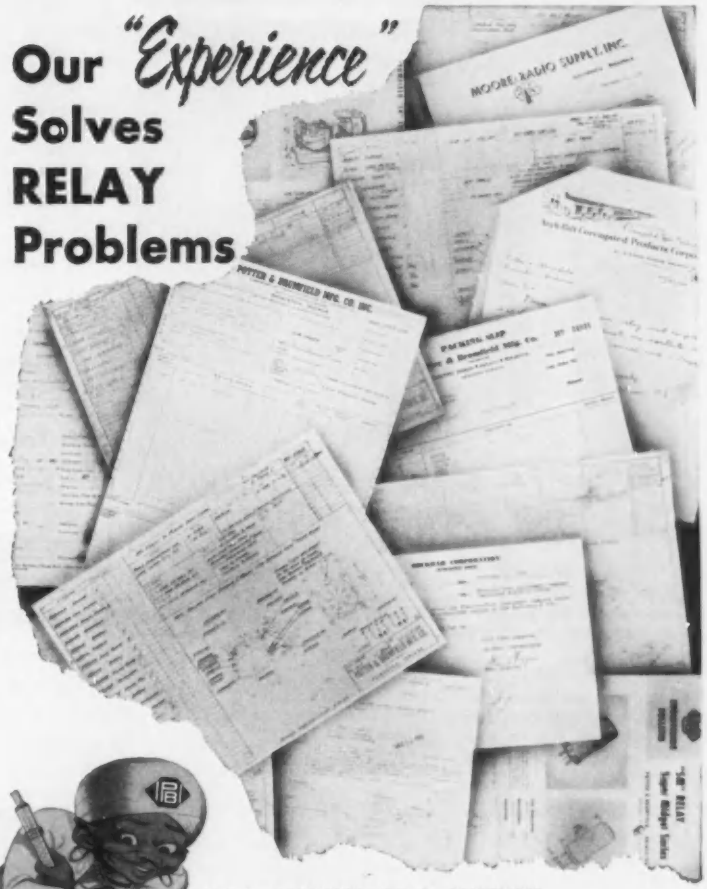

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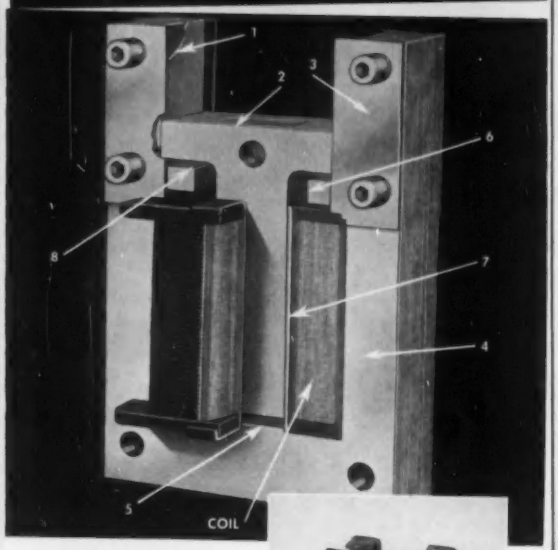

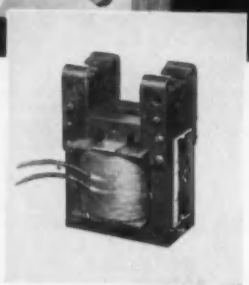

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1 lb. to 300 lbs. at 85% voltage; 1.4 lbs. to 420 lbs. at 100% voltage. Strokes ½" to 1½"

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By the use of heavy non-magnetic metal guides (1 & 3) for plunger head (2) the following advantages are obtained:

(a) All possibility of magnetic sticking and dragging is eliminated;

(b) No heavy grease lubrication for plunger is required;

(c) Solenoid may be mounted in any position and at any angle to the vertical, without in any way affecting its operation or the length of its useful life;

(d) It is not necessary to make the plunger (2) precision fit to the frame; (4)

(e) When mounting the solenoid it is not necessary to align it precisely to eliminate side thrusts in plunger head;

(f) With 1/16" thick non-magnetic metal guides (1) between plunger head and frame, the guides must wear 1/16" before magnetic sticking and dragging sets in, whereas, without non-magnetic metal guides, only a few thousandths of an inch combined wear of plunger head and frame are required to start magnetic sticking and dragging and to render the solenoid unreliable and inoperative;

(g) Thus the life expectancy of the solenoids is increased manyfold and the solenoid remains completely reliable throughout its life;

(h) It is fairly well established that the guides of the type and thickness we use outlast the rest of the solenoid.

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By the use of three contact surfaces, all of them pole shaded, the solenoid can be made as quiet as desired without any difficulty.

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The use of three impact surfaces triples the life of the solenoid as compared with similar solenoid using only one impact surface, even if that one impact surface be provided with a tool of hard metal.

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Write for Bulletin EE 178-A

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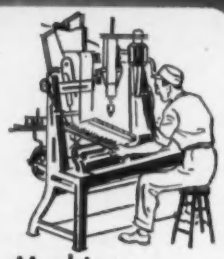

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NEW BOOKS

Electronic Engineering

SAMUEL SEELY, *Professor and Chairman, Dept. of Electrical Engineering, Syracuse University.* 9¼ x 6¼ *in., 525 pp. Published by McGraw-Hill Book Co., 330 W. 42 St., New York 36, N. Y.* $8.

The book begins with a general introduction to tubes and tube circuit principles, and then proceeds into a detailed consideration of more important electron tube circuits in such diverse fields as radar, television, electronic control and instrumentation, and computers. Emphasis is placed on physical and mathematical analyses.

In all analyses, care has been taken to include requisite reference conditions for potential polarities, current directions and transformer-winding sense. Although most of the text is devoted to circuit operation analysis, factors that must be considered in circuit and system synthesis are also discussed.

Occasional alternate methods of analysis of a given circuit are included and varied analytical methods are employed in developing the material. Examples and problems are used to relate the theoretical developments with practical situations.

Professional Engineer's Examination Questions and Answers

WILLIAM S. LALONDE, JR., *Newark College of Engineering.* 5½ x 8¼ *in., 462 pp. Published by McGraw-Hill Book Co., 330 W. 42 St., New York 36, N. Y.* $6.50.

Over 500 questions are here selected from or patterned on recent examinations for the professional Engineer License, the Land Surveyor License, and the Engineer-in-Training Certificate. Many are composites of the more complex questions found in professional engineering examinations all over the United States. For every question a detailed answer is supplied

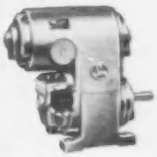
(Continued on page 436)

...STERLING SPEED-TROL VARIABLE SPEED MOTORS

Sterling Speed-Trol Variable Speed Motors are fundamental to the success of any manufacturing operation involving changing production conditions. Speed-Trols give machinery the versatility which assures optimum productivity regardless of manufacturing variables. They also prevent obsolescence of machinery due to changes in processes or production volume. As insurance against future or unanticipated changes, it will pay you to investigate Sterling Speed-Trol Variable Speed Motors. They have your production future built into them.

Write today for Bulletin No. 188. Discover the big advantages Sterling Speed-Trol Variable Speed Motors can bring to your plant.

Sterling offers you a wide range of Electric Power Drives of advanced design—variable speed or constant speed—with manual or automatic controls.



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Standard 12 stop Intermittor with specially jig-bored 36" dial.

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Few production machines can . . . but it's possible with the Ferguson Intermittor Index Table. There are models capable of 30,000 indexes an hour if your machinery and tooling can keep up with them. The point is . . . *the Intermittor does not limit the speed of your machinery the way geneva driven or air or hydraulic operated tables do.*

Perhaps speed is not your problem, but excessive maintenance costs are . . . resulting from the clanging, banging and jarring you get from a geneva drive. Here again you find the solution in an Intermittor. Employing modified trapizoid acceleration characteristics, the Intermittor has an initial acceleration point of zero with a gradual increase to the maximum and an equally gradual decrease to zero again . . . *all of which means that the Intermittor is a smooth operating table with minimum shock and vibration.*

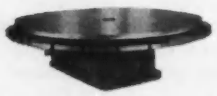
Or maybe you like accuracy . . . but don't like shot pins. The Intermittor Indexing mechanism has an accuracy of .001" with zero backlash — *and no shot pins!*

There are many more reasons why you should install an Intermittor when you need a rotary table for large volume production, including the fact that you can select one of 150 standard models from a catalog and get exactly what you need in terms of dial size, number of stations and indexing period.

OVER 150 STANDARD MODELS TO CHOOSE FROM:

Standard 24 station Intermittor with 30" dial and optional stationary tooling plate above the dial.

6 station Intermittor with 12" dial and special tool mounting brackets.



Standard 18 station Intermittor with 48" dial.

Send for our Catalog No. 300 . . . it has a definite place in your file if you have the responsibility of speeding up production or converting to automation.

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ROLLER GEAR DIVISION, DEPT. BI-5 P. O. BOX 5841, ST. LOUIS 21, MO.

of the type examiners accept and credit.

No attempt is made to supply the reader with the fundamental engineering knowledge which he should have derived from college courses and engineering experience. The questions and their answers (separated by over 100 pages of text) are intended for practice in handling the types of problems likely to be asked of a fully qualified engineer or land surveyor.

In addition to questions on basic engineering fundamentals, groups of questions are devoted to chemical, electrical, mechanical and structural engineering as well as engineering economics and land surveying.

Modern Physics

ROBERT L. SPROULL, *Associate Professor of Physics, Cornell University.* 6 x 9¼ *in.*, 491 *pp. Published by John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N. Y.* $7.75.

The aim of this book is to present to engineers those parts of twentieth-century physics which are of greatest importance in engineering. The research of the last fifty years has not only changed our understanding of physics but has also produced from this understanding devices and processes vital to present-day engineering. This book describes the modern physics of electrons, atoms, and nuclei and applies this basic physics to problems of engineering interest. There are many additional and equally important applications of modern physics in engineering, such as, for example. applications to the electrical, thermal, mechanical and magnetic properties of solids and to the electrical and chemical properties of surfaces.

Developed from notes used in a course for engineering undergraduates at Cornell and in courses for practicing engineers at Westinghouse, Corning Glass and Sylvania, the book is analytical in its approach. The crucial experiments are analyzed and the elementary theory underlying the properties of atoms, molecules, solids and nuclei is based on this analysis. The analysis is carried far enough o that the "new" physics can be applied to understanding processes (such as thermionic emission or the nuclear

(Continued on page 439)

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..for accuracy
..to eliminate warpage

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STRESSPROOF®

severely cold-worked, furnace-treated
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The generator shaft for this Miller Electric Arc Welder is made of STRESSPROOF because:

1. It has the required accuracy. Generator shafts have very close tolerances. When ground and polished STRESSPROOF is used, no expensive finishing operations are required. Simply machine the ends, cut the keyway, knurl and assemble.
2. STRESSPROOF machines faster and smoother than other high strength steels.
3. STRESSPROOF eliminates warpage which often occurs during machining of long keyways.
4. STRESSPROOF offers the increased strength without heat treating.
5. STRESSPROOF makes a better part at lower cost.

In addition to a beautiful finish and carefully controlled accuracy, ground and polished STRESSPROOF provides four important in-the-bar qualities: (1) High Strength, (2) Machinability, (3) Wearability, (4) Minimum Warpage. It is available in either cold-drawn or ground and polished finish.

The outstanding quality and accuracy of ground and polished STRESSPROOF made a better generator shaft for this arc welder manufactured by Miller Electric Manufacturing Co., Inc., Appleton, Wisconsin

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Shop Talk

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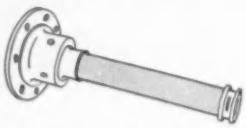
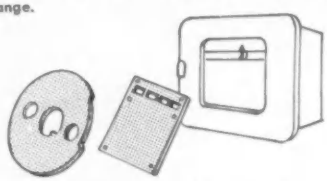
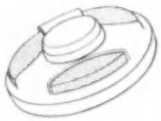
Tips for designers



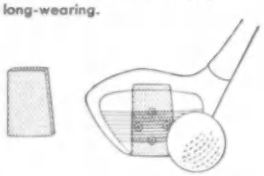
Aircraft fuel gage tank unit uses a tube of Taylor Epoxy Glass Base Laminate . . . an unusual material noted for excellent corrosion resistance and electrical insulation over a wide humidity range.



Cam and terminal board for recording instrument, made of Taylor Grade XP Laminate . . . noted for its electrical insulating properties and ease of machining.



Fuel pump valve seat . . . Taylor Grade LE phenol laminate resists attack by gasoline . . . tough, long-wearing.



Insert in face of golf club, made of Taylor Vulcanized Fibre, withstands severe impact . . . gives long-lasting, long-hitting surface.

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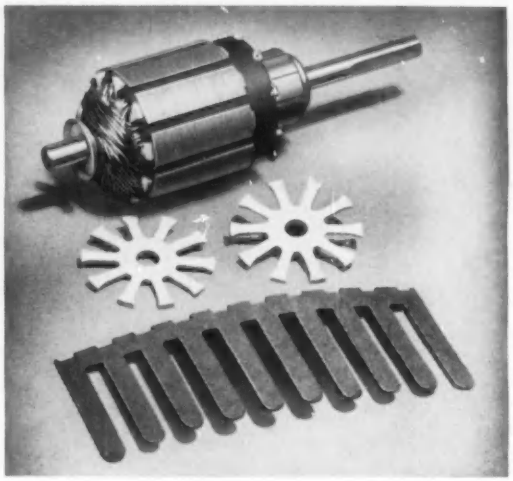
Your production can be simplified . . . schedules safeguarded . . . inventory headaches cured . . . and overall costs reduced by having Taylor fabricate finished parts to your specifications. Efficient, modern facilities are ready to serve you. Get in touch with Taylor about your requirements.



Toughness, flexibility and dielectric strength are required for insulation for motor armature windings. Taylor Insulation and Commercial Grade Vulcanized Fibre serve ideally for slot wedges, topsticks and end laminae . . . and paper-base tube for the thrust bushing.

For tough, pliable insulation -try Taylor Vulcanized Fibre

You probably have a product design job on hand right now that could gain from the economy, machinability, and performance advantages of Taylor Vulcanized Fibre. In the application shown above, Taylor Vulcanized Fibre was chosen for its high impact strength, excellent bending qualities, and outstanding insulating properties. Designers are putting its wide range of properties to work in new, demanding applications every day.

It's a rugged material—tough enough to withstand heavy wear and abrasion, yet resilient enough to take heavy pounding. You can use it to advantage in gaskets, washers, cams, workbench tops, abrasive discs, and structural parts.

It has high arc resistance and dielectric strength—an ideal material for use in electric motors, transformers, appliances, circuit breakers, and switches.

In any of its applications, Taylor Vulcanized Fibre brings important savings in fabricating. It's readily formed . . . easily punched, stamped, drilled, cut.

From the many grades of Taylor Vulcanized Fibre, you can choose the properties needed for your job. It's supplied in various colors . . . in rolls, strips, and turned rods . . . and in the largest sheet size in the industry.

Check with your Taylor representative for help in gaining the many benefits of this versatile material for your own products.

reactor), instruments (such as the optical pyrometer or the mass spectrometer), and the properties of materials (such as ferromagnetic materials or semi-conductors).

The book is organized either for self-study or for a formal program. It features a large number of problems with a wide range of difficulty and offers a good selection of references at the end of each chapter. Mks units are employed throughout. One of the several helpful appendices gives simple instructions for converting to cgs units.

Tensile Deformation of Molybdenum As a Function of Temperature and Strain Rate

R. P. Carreker, Jr., and R. W. Guard, *General Electric Research Laboratory.* 8¼ x 10¾ *in.*, 26 *pp, paper bound. Published by U. S. Dept. of Commerce, Office of Technical Services, Washington 25, D. C.* $1.

This report was prepared by the General Electric Co., Research Laboratory under a USAF contract.

True stress—true strain data are reported for nominally pure molybdenum (99.95 per cent) over the temperature range from −196 to 1540 C (0.027 to 0.63 T/T_m). Strain-rate sensitivity was determined by rate-change tests and stress-relaxation tests. Inhomogenous yielding and strain-aging effects were observed. The yield stress and tensile strength depend markedly on temperatures below 400 to 800 C. The ductile-to-brittle transition range is 25C to −25 C. Strain-rate sensitivity and stress-relaxation effects are very large near room temperature.

Proceedings of the Second U. S. National Congress Of Applied Mechanics

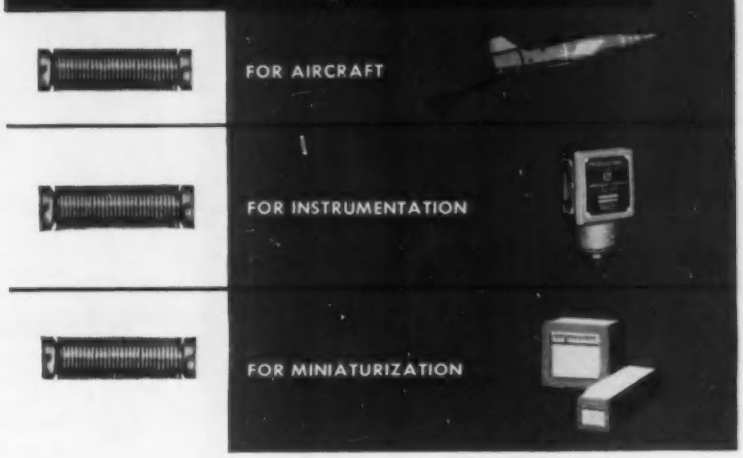
9 x 11 *in.*, 821 *pp. Published by American Society of Mechanical Engineers,* 29 W. 39 St., *New York* 18, *N. Y.* $9.

This volume contains the 99 papers which were presented at the Congress held in Ann Arbor at the University of Michigan from June 14 to 18, 1954.

The proceedings consist of four

(Continued on page 441)

Engineering News from Bridgeport Thermostat



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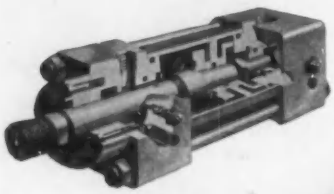

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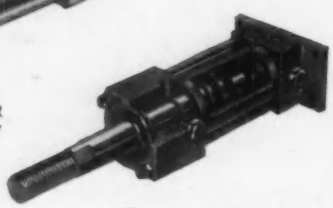

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invitation general lectures and technical papers which were accepted by the editorial committee upon recommendation of expert reviewers in the various branches of applied mechanics. The technical papers are divided into four general categories:

(1)—General Methods, dynamics, vibration, wave motion

(2)—Elasticity, shells, plates, elastic instability, structures

(3)—Plasticity, viscoelastic flow, failure, behavior of materials

(4)—Fluid flow, aerodynamics, heat transfer

Materials Handbook—8th Edition

GEORGE S. BRADY, *former Consultant and Engineer.* 9¼ x 6¼ *in.*, 1022 *pp. Published by McGraw-Hill Book Co. Inc.*, 330 W. 42 St., *New York* 36, *N. Y.* $11.

This handbook gives data on approximately 10,000 materials. It presents pertinent facts on metals, alloys, refractories, abrasives, woods, and others—all arranged and indexed for quick reference.

The most essential and useful facts for purchasing agents, engineers, executives are given, rather than an exhaustive treatise on each material. Chief characteristics, comparative data, sources, substitutes, adulterants, and uses for each are provided.

Part II presents basic information on the economic geography of materials resources, weights, measurements, physical comparisons on the various materials, enabling the purchasing agent not only to see the administrative "how" of buying materials but also to understand the "why" in fundamental, clear terms.

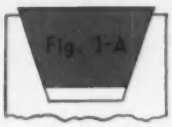
Nuclear Metallurgy, Vol. II

8½ x 11 *in.*, 94 *pp. Published by American Institute of Mining and Metallurgical Engineers, Inc.*, 29 W. 39 St., *New York* 18, *N. Y.* $3.75.

This book gives the latest information on the behavoir of metallic materials in the corrosive conditions encountered in nuclear reactors. Included are six articles by authors presenting technical papers at a sympo-

(Continued on page 445)

Concave sides make V-belts last longer



The sides of every Gates V-belt (Fig. 1) are concave—a precisely engineered curve that greatly increases V-belt life. Here's why:

On the bend around the sheave, the concave sides of a Gates V-belt fill out and become straight (Fig. 1-A). Thus the belt makes full contact with the sides of the sheave, grips the sheave evenly, and wear is distributed evenly across the sides of the belt. Uniform wear lengthens belt life; keeps costs down.

Make this simple test

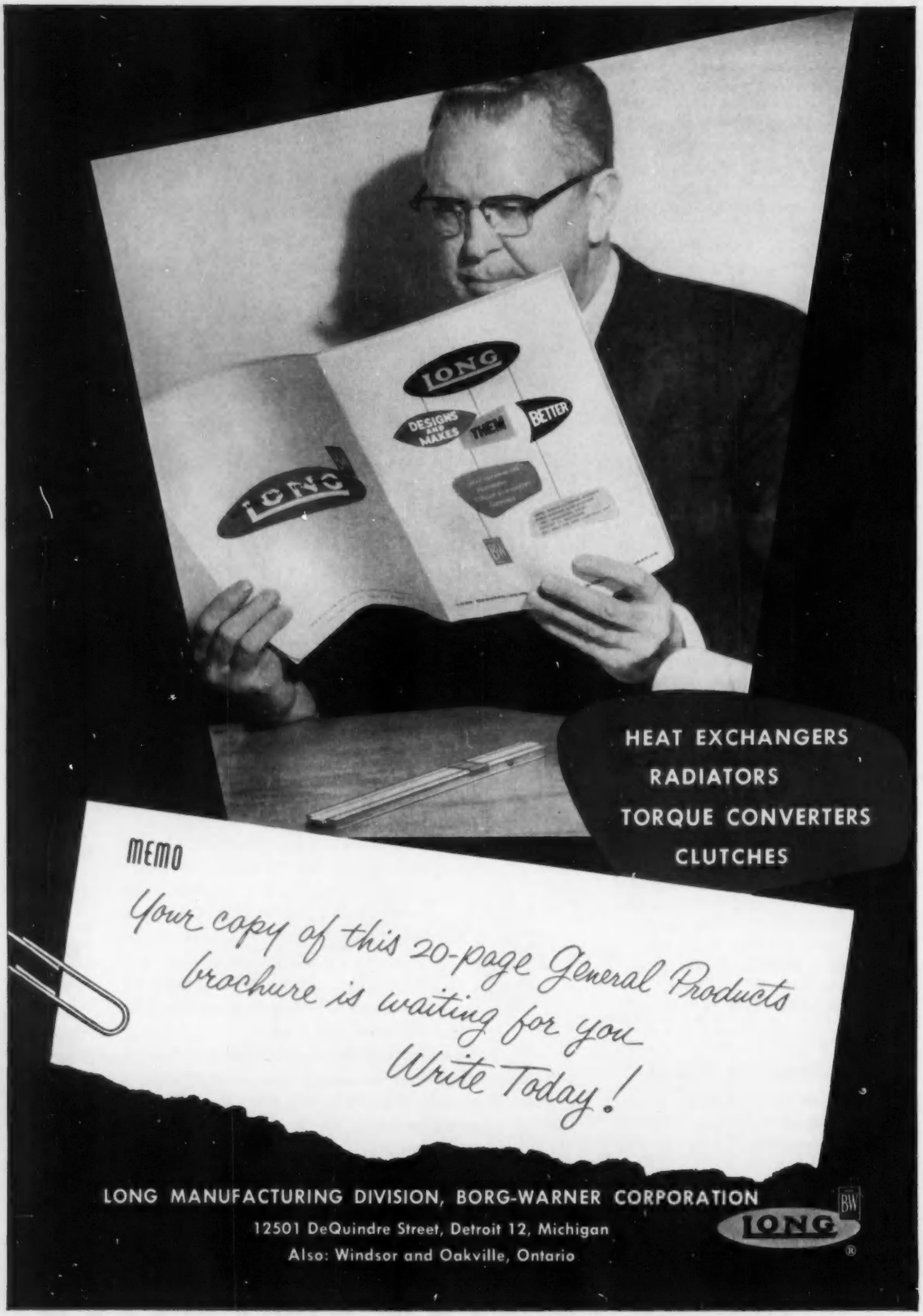
Take a straight-sided belt (Fig. 2) and bend it. Feel the sides at the bend; they bulge out. Now picture this bulge in the sheave groove (Fig. 2-A). It is easy to see that the belt makes uneven contact at points indicated by arrows. Naturally, wear is greater at these points. Uneven wear shortens belt life; increases belt costs.

Cut down-time and V-belt replacement costs. Specify belts that grip evenly and wear longer . . . specify Gates Vulco Rope—the V-belt with concave sides. There is a Gates distributor nearby who will quickly supply the belts you need. The Gates Rubber Co., Denver, Colorado

—*World's Largest Maker of V-Belts*

TPA 60

Gates VULCO ROPE Drives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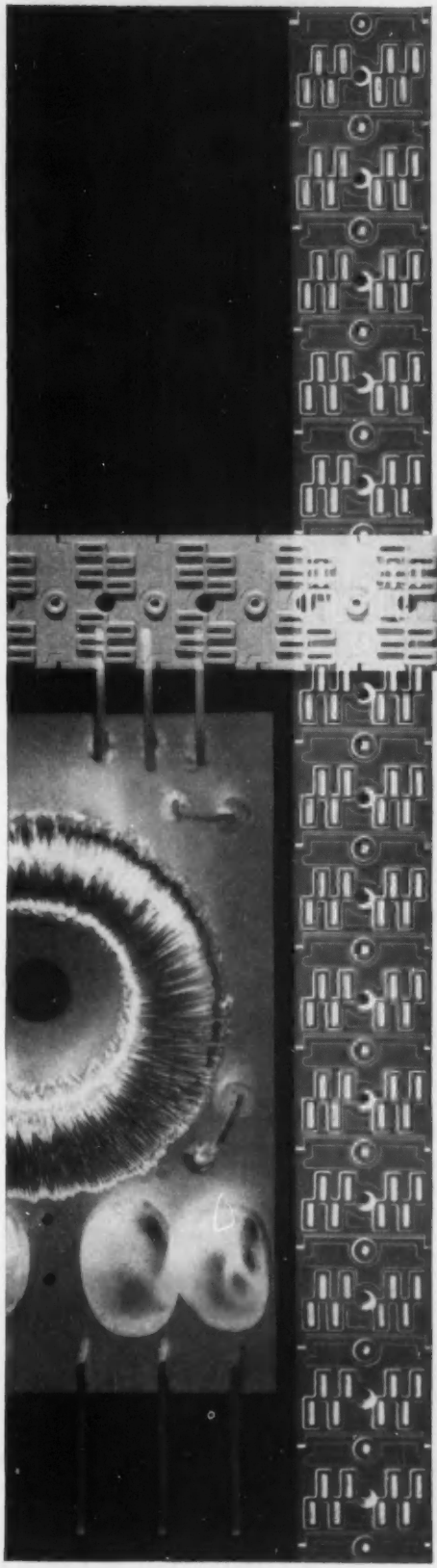

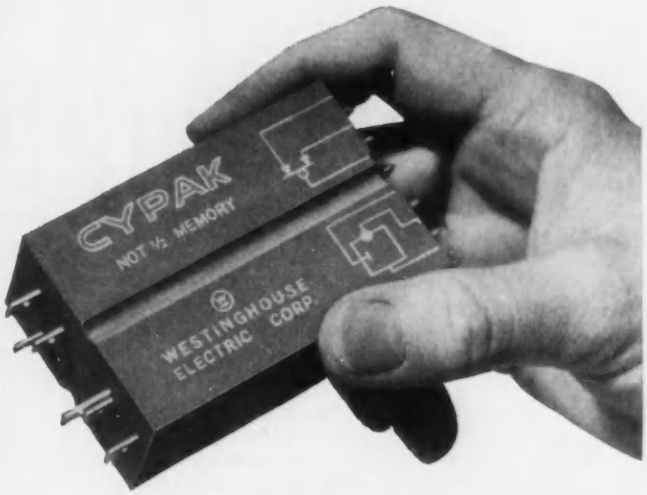

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Dynamics—Experienced flutter engineers required for work on a variety of dynamics problems including flutter models, analytical work involving electronic computers, and methods development.

Loads—Exciting and diversified assignments in the fields of both piloted and pilotless aircraft are now available in Structural Loads Group for engineers of all experience levels.

Stress Department—Experienced Structural Engineers for positions on Long Range Interceptor Project and on advanced missile designs.

A wide diversification of assignments within each field of specialization awaits the men capable of filling the above assignments. Responsibilities will include work on many phases of missile and aircraft design, guidance systems and boundary layer research.

If you qualify for any of these challenging opportunities, we invite you to contact Manager of Engineering Industrial Relations, Northrop Aircraft, Inc., Hawthorne, California, or call ORegon 8-9111, Extension 1893.

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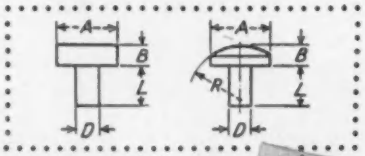
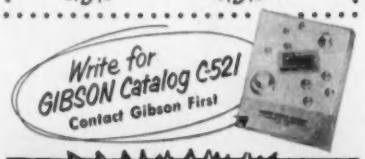
  Simple, practical design of Gibson contact rivets combines with quality materials to provide flawless performance. For rivet quotation, submit dimensions shown and desired quantity.





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sium on nuclear metallurgy conducted by the Institute of Metals Div. of AIME during the annual meeting held in New York on Feb. 20, 1956. These are: "General Problems in the Application of Materials in Reactor Environments" by R. C. Dalzell, AEC; "The Behavior of Materials in Aggressive Liquid Metals" by D. H. Gurinsky, Brookhaven National Laboratory; "Behavior of Materials in Nonaggressive Liquid Metals" by R. F. Koenig and E. G. Brush, General Electric Co.; "The Application of Materials in Low Temperature Water and Organic Liquid Cooled Reactors" by J. E. Draley and S. Greenberg, Argonne National Laboratory; "Structural Materials for Use in the Pressurized Water Power Reactor" by D. M. Wroughton and D. J. DePaul, Westinghouse Electric Corp.; "Corrosion of Materials in Fused Hydroxides" by G. P. Smith, Oak Ridge National Laboratory.

Tables of Thermal Properties of Gases

JOSEPH HILSENRATH, C. W. BECKETT, W. S. BENEDICT, LILA FANO, H. J. HOGE, J. F. MASI, R. L. NUTTALL, Y. S. TOULOUKIAN, and H. W. WOOLLEY. 8 x 10½ in., 479 pp. *Published by National Bureau of Standards, Circular 564, (Order from the Government Printing Office, Washington 25, D. C.)* $3.75.

One of a series of compilations of thermodynamic and transport properties of gases published by the NBS, this collection of tables covers air, argon, carbon dioxide, carbon monoxide, hydrogen, nitrogen, oxygen and steam. Tables are given at close temperature intervals for the thermodynamic and transport properties of the gases covered. The thermodynamic properties—compressibility factor, density, entropy, enthalpy, specific heat, specific-heat ratio and sound velocity—are tabulated for the real gas at pressures up to 100 atmospheres and to temperatures of 600 K for hydrogen, 1500 K for carbon dioxide, 850 K for steam, and 3000 K for the remainder. The ideal-gas thermodynamic functions are tabulated uniformly to 5000 F.

Also tabulated are the vapor pres-

(Continued on page 449)

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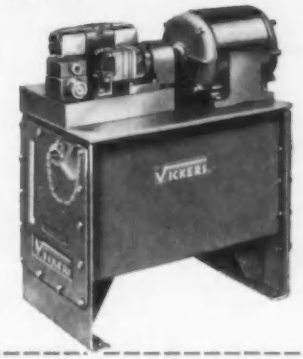
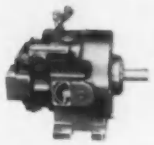
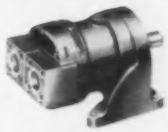


V-LINE PISTON PUMPS AND MOTORS for 5000 psi. Unique design minimizes relative movement between rotating parts, provides increased bearing surfaces and reduces complexity of parts. Result is improved efficiency, longer life, and reduced maintenance. Supplied with straight thread connections. Bulletin 55-72.

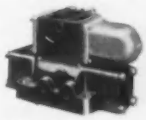


Variable Displacement Pump With Servo Control. Inst. Dwg. 179061. Also available with pressure compensator control. Inst. Dwg. 179060.



Constant Displacement Fluid Motor. Inst. Dwg. 179059. Available also is a Constant Displacement Piston Pump. Inst. Dwg. 179058.

DG4S4 ⅛" solenoid operated. Inst. Dwg. 182412. ¼" available later.



DG5S4 ¼" solenoid controlled pilot operated. Inst. Dwg. 182413. 1¼", 2", 3" available later.

SOLENOID OPERATED 2- AND 4-WAY VALVES with many improved features. (1) Integral junction box (2) covers that retain the solenoids and (3) manual operation for testing. Compact and versatile. Gasket mounting simplifies installation and overhaul . . . also minimizes piping.

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CG-03 Relief Valve (gasket mounted). Subplates available with pipe or straight thread connections. Inst. Dwg. 175630. CS-03 available with straight thread connections. Inst. Dwg. 175629.

C02 Reciprocating Cycle Control Panel For Gasket Mounting. Inst. Dwg. 177083.

4CG-03 Pilot Operated Check Valve, gasket mounted. Inst. Dwg. 135468.

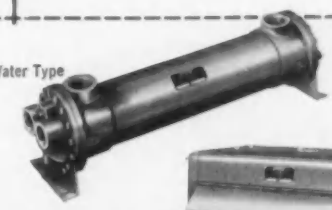
CG-714 Deceleration Valve, gasket mounted. Inst. Dwg. 172902.

CGV-06 5000 psi Relief Valve gasket mounted with straight thread connections. Inst. Dwg. 177609.

URG1 Unloading Relief Valve, gasket mounted. Inst. Dwg. 178974.

SG1 Pressure Switch, gasket mounted. Inst. Dwg. 172538.

Water Type



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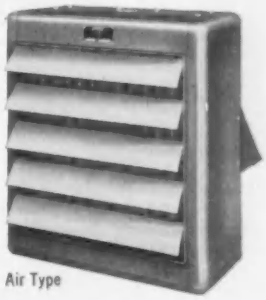

Air Type

For further information on any unit shown, ask for Installation Drawing by number indicated.

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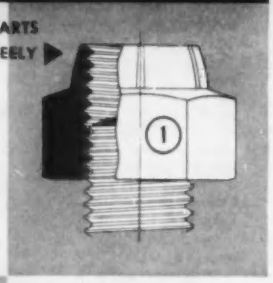
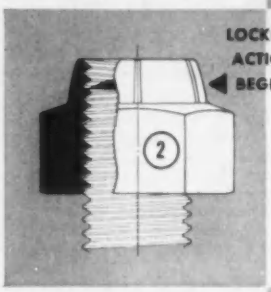
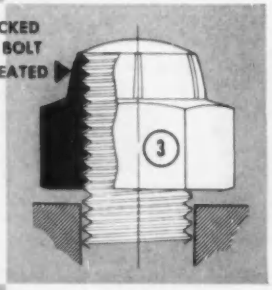
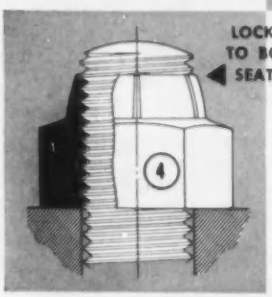




friction lock, between the load carrying flanks of the nut and the bolt threads. The combined metal to metal hugging and locking friction is distributed over all of the threads, enabling "HUGLOCK" to grip the bolt firmly, until removed by a wrench . . . The one-piece all metal construction and the continuous thread, extending through the length of the nut, provide maximum thread shear strength. The "HUGLOCK" principle can be incorporated into nuts of standard size, with standard threads or special sizes with special threads . . . "HUGLOCK" maintains its locking action, through repeated re-





movals or re-use on the same bolt or a similar bolt of commercial thread tolerance. It locks to the bolt, whether the nut is seated or unseated. "HUGLOCK" eliminates axial thread play which tends to make a nut creep from its seat and work loose, under severe vibration or shock . . . All lock washers, cotter pins, key plates and other locking devices can be eliminated . . . The "HUGLOCK" section of our catalog contains 24 pages. It includes complete information, specifications, engineering data, prices; will be furnished on request.

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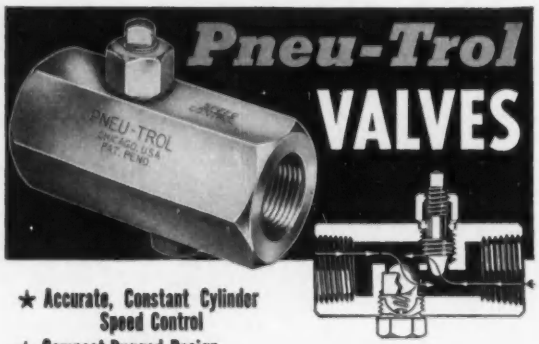

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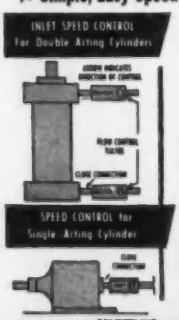

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sures and transport properties, thermal conductivity, viscosity and Prandtl number. These were fitted either semi-theoretically or empirically to the experimental values and are tabulated over the range of the available experimental data.

Comparisons of the tabulated values with the existing experimental data are shown in deviation plots which exhibit the range and distribution of the experimental data as well as their agreement with the tabulated values.

Through the Mathescope

C. Stanley Ogilvy, *Asst. Professor of Mathematics at Hamilton College. 8¾ x 6 in., 162 pp. Published by Oxford University Press, 114 Fifth Ave., New York 11, N. Y. $4.*

This book is designed to acquaint the layman, whose taste for the subject may be soured or underdeveloped, with the intellectually stimulating and aesthetically satisfying aspects of mathematics. Mr. Ogilvy seeks to throw light upon the various branches of the field, and he explains their interconnections. He presents mathematics as a subject with constantly broadening frontiers. The illustrations and examples are many, including both old favorites and new ones current enough to explain in simple terms a number of the mathematical advances of recent years. Light reading for the professional or advanced mathematician.

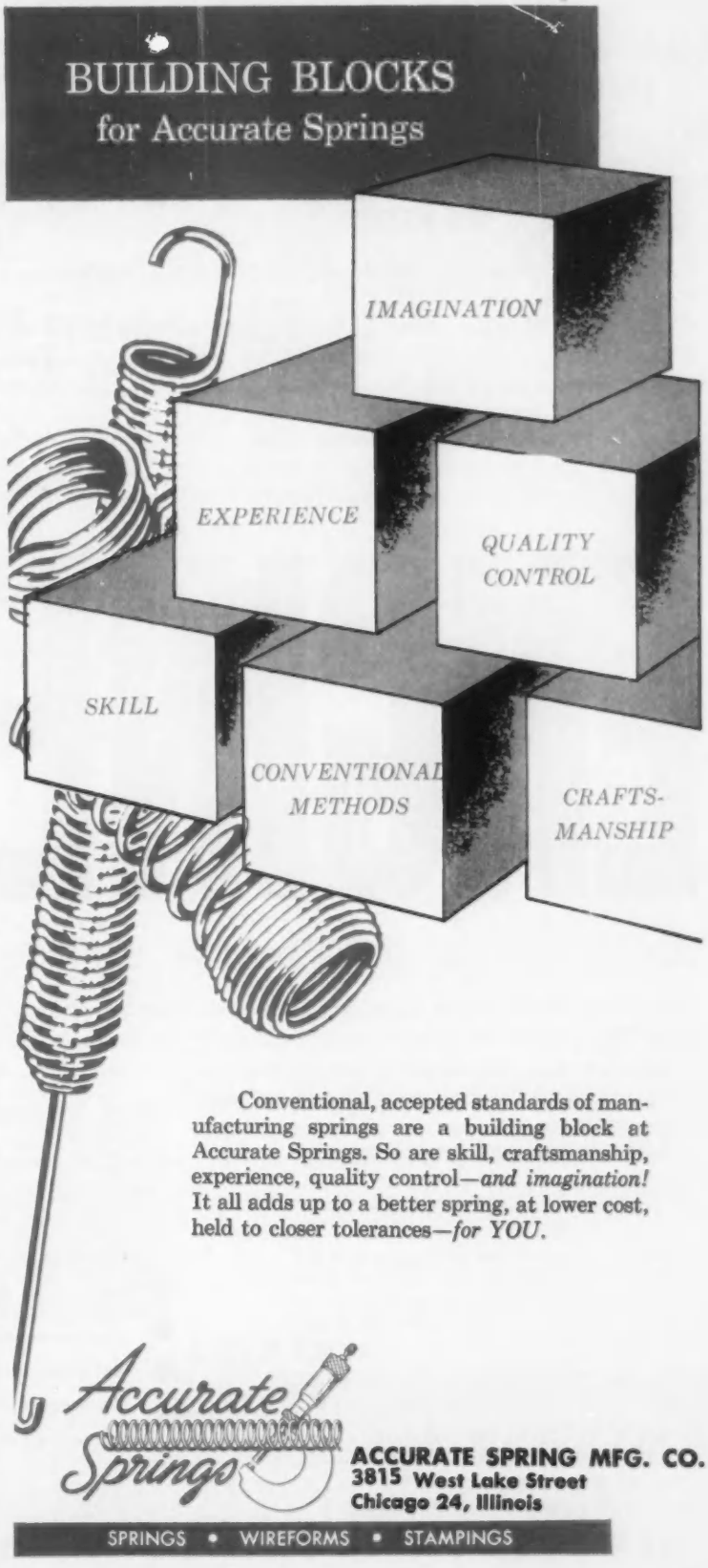
Structural Changes of Commercial Titanium and Titanium-Base Alloys On Heat Treatment

D. W. Levinson, W. Rostoker, *Armour Research Foundation, Illinois Institute of Technology. 10¾ x 8¼ in., 113 pp. Available from U. S. Dept. of Commerce, Office of Technical Services, Washington 25, D. C. $3.25.*

This report was prepared under Contract AF 33(038)-16347 and is intended to develop a fundamental understanding of principles upon which the heat treatability of titanium-base alloys may be founded.

The program described here was designed to determine the microstruc-

(Continued on page 453)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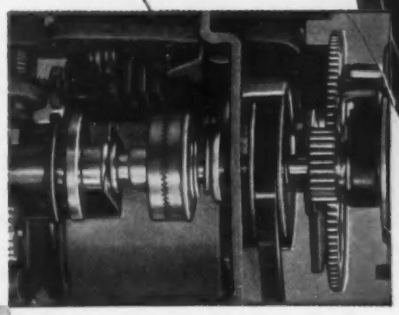

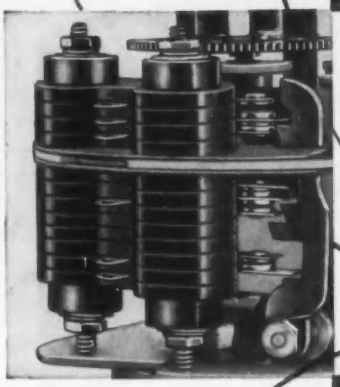

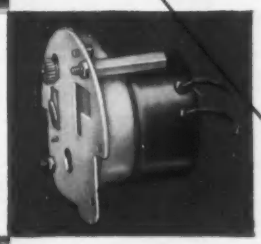

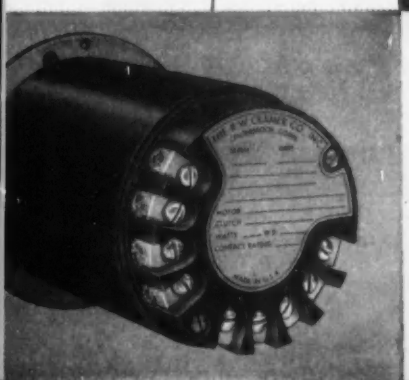

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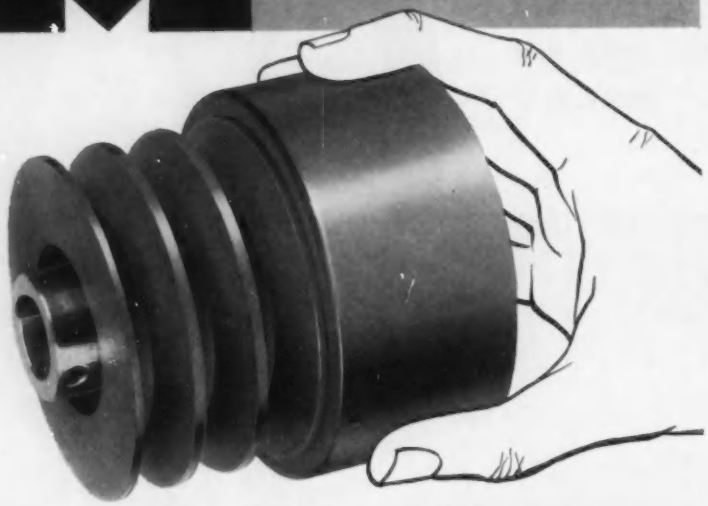

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Information on Mercury's line of automatic or special manual clutches for gasoline or electric equipment, will also be sent promptly on request.

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Pulley Dimensions	3½"x2 AB	4"x3 AB

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tural configurations representing conditions for optimum strength, optimum ductility, and the optimum strength-ductility ratio. Tensile and impact properties, and microstructures of three representative alloys heat-treated according to schedules dictated by the TTT curves are presented. Influence of dispersed carbides on grain growth characteristics and tensile properties of three representative titanium-molybdenum alloys are charted.

Effect of Grain Size on The Mechanical Propertes of Titanium and Its Alloys

FRANK C. HOLDEN, HORACE R. OGDEN, and ROBERT I. JAFFEE, *Battelle Memorial Institute.* 10½ x 8¾ *in.*, 139 *pp. Published by Wright Air Development Center, Air Research and Development Command, United States Air Force, Wright-Patterson Air Force Base, Ohio.* $3.75.

This report was prepared under USAF Contract No. AF 33(616)-412 and summarizes the research done to determine how variations in grain size and shape would effect the mechanical properties of 'itanium and representative titanium-base alloys. The mechanical properties of interest were those that describe fabrication and performance capabilities and that also may be affected by grain size. These include tensile properties, hardness, bend properties, flow properties, impact properties and fatigue endurance limits.

Data are presented chiefly by the use of graphs to supplement the text. Complete tabulated data and flow curves are given in the appendixes.

Electrical Circuits

CHARLES S. SISKIND, *Assistant Professor, Purdue University.* 9¼ x 6¼ *in.*, 516 *pp. Published by McGraw-Hill Book Co.*, 330 W. 42 *St.*, *New York* 36, *N. Y.* $6.75.

This text is concerned with fundamental principles of electric and magnetic circuits for the student who wants to prepare for advanced studies in machinery, power distribution systems, electronic circuits, control

(Continued on page 457)

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brightens zinc die castings by chemical polishing, protects against corrosion

NOW, FOR THE FIRST TIME you can get a brilliant, decorative finish directly on zinc die-cast parts . . . without mechanical finishing, without electroplating! The luster is provided by the *chemical polishing* action of new Iridite (Cast-Zinc-Brite) solution. Even surface blemishes, such as cold shuts, are brightened by this new process. No electrolysis. No special equipment. No specially trained personnel. Just a simple chemical dip for a few seconds and the job is done. And, this new Iridite has been *tested and proved* in production.

CORROSION RESISTANCE, TOO! New Iridite (Cast-Zinc-Brite) provides exceptional corrosion resistance for bright-type chromate finishes . . . also guards against blueing or darkening by eliminating zinc plate formerly required in bright chromate finishing of zinc die castings.

AS A BASE FOR ELECTROPLATING—Lower mechanical finishing costs are possible where plated finishes are *required* since the brightness provided by this new Iridite may be sufficient.

LET US SHOW YOU what Iridite (Cast-Zinc-Brite) can do for you. Send us at least a half-dozen typical zinc die-cast parts for FREE PROCESSING for your own tests and evaluation. Or, for immediate information, call in your Iridite Field Engineer. He's listed under "Plating Supplies" in your classified 'phone book. *IMPORTANT: when you give us samples for test processing, please be sure to identify the alloy used.*

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Write to: Sutco, Original Equipment Division.

There is something NEW in motors!

Sutco has added to their standard line of shaded-pole motors *a complete new concept of permanent split-capacitor motor design*... the ***Mini-Lap**... designed to set new standards for minimum motor cost... plus higher efficiency... ratings through ⅓ H. P.

Sutco Standard Shaded-Pole Motor Ratings Are:

- 2 Pole – up to 1/60 H. P.
- 4 Pole – up to 1/10 H. P.
- 6 Pole – up to ¼ H. P.

* Patent Pending

Sutco ORIGINAL EQUIPMENT

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Parts molded of C-11 Plastics for
International Business Machines Corp., New York 22. N. Y.

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key buttons, platen knobs, space bars, and switch levers

Typewriter parts that are most on view get the most abuse. But they never show it on this new electric typewriter. Buttons, keys, switches, and bars are all molded of BAKELITE Brand C-11 Plastic, a styrene-acrylonitrile copolymer.

C-11 replaced older materials because it resists staining by ink, oil, carbon paper, and cleaning fluid. It withstands abrasion by operators' fingernails.

BAKELITE C-11 Plastic produces parts that are formed with a high degree of uniformity and accuracy and do not warp or swell. The white characters on the keys illustrate this feature. The outer block of gray C-11 is molded hollow, with the character opening through to the top. An insert of white C-11 is molded into it from the under side, and formed with a slot to fit the key arm. Notice the clean details of this two-shot molding.

BAKELITE C-11 Plastics have the combination of molding accuracy, toughness, eye-appeal, and chemical resistance that you may want for your product or part. To learn more, write Dept. PN-145.

BAKELITE
BRAND
C-11 PLASTICS

See BAKELITE'S exhibit, booths #809, 813, 817, 825, National Plastics Exposition, June 11-15, 1956, New York Coliseum, New York

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You'll have a chance to explore first-hand some of the potentials of glass as a more-useful-than-commonly-thought-of material.

DESIGN ENGINEERING SHOW

We'll be on hand to demonstrate properties, methods of manufacture — and to answer your questions.

P.S. If you are not going to be at the show, wend your way to New York State's picturesque Southern Tier sometime this Spring or Summer and visit the Corning Glass Center. Here also may be seen some of the newest uses for glass, as well as the oldest. Drop us a note and we will be glad to send you a preview of what may be seen here.

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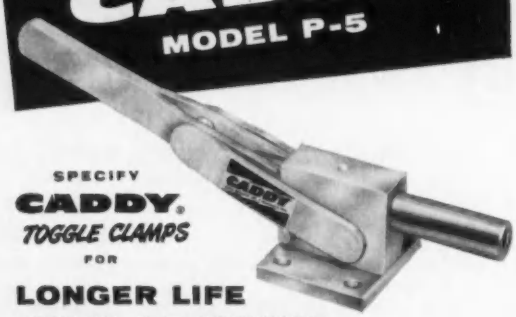

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equipment, and other devices of an electrical nature.

The material is divided into two major parts; one deals with circuits in d-c systems, while the other is concerned with circuits in a-c systems.

The presentation of electric and magnetic circuits involves a blending of descriptions and rigorous-mathematical analyses. Emphasis is placed upon practical applications and operations, in connection with which numerous examples are worked out to illustrate significant points.

Discussions are approached from the point of view of circuit arrangements encountered in the operation of practical systems, devices and machines. Illustrative examples and problems are presented to simulate electric and magnetic circuits. Included is an appendix of mathematical derivations involving the use of the calculus.

Constitution of Titanium Alloy Systems

MAX HANSEN, DONALD J. MCPHERSON, WILLIAM ROSTOKER, *Armour Research Foundation of Illinois Institute of Technology.* 8 x 10½ *in.*, 251 pp, *paper bound. Published by the U. S. Dept. of Commerce, Office of Technical Services, Washington 25, D. C.* $8.

With the advent of titanium and its alloys as potential engineering materials, there came a realization of the need for fundamental information, particularly phase diagrams, as a prerequisite to fruitful alloy development. Accordingly, during recent years the constitution of many titanium alloy systems has been studied. Much of this work has been conducted under the sponsorship of government agencies, including the Wright Air Development Center. In accordance with the suggestion of Mr. J. B. Johnson, Chief, Metallurgy Research Group, Flight Research Laboratory, WADC, a project was initiated with the purpose of compiling and evaluating all of the titanium phase diagram information available to date, as a service to government agencies and industries active in the over-all titanium program.

Data on the phase relationships of the various systems have been com-

(Continued on page 461)

Do you need brake blocks to stop a 600 horsepower oil drilling drawworks . . . *or* small friction units to control the cycles of an automatic washer?

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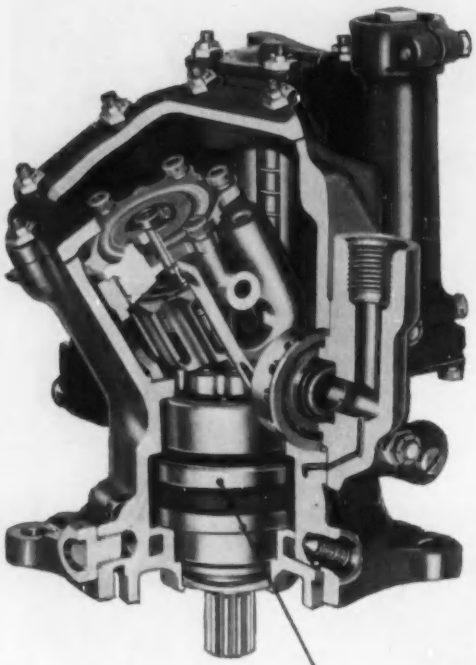
ONE AETNA BEARING DOES A FORMER *TWO* BEARING JOB



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A LIGHTER, SMALLER PUMP WITH FEWER PARTS ***PLUS*** *IMPROVED PERFORMANCE AND RELIABILITY*

This recently improved variable displacement piston type pump packs more power in less space than any other pump made—has, in fact, notably higher efficiency with a third less of the weight and size of its previous design.

To achieve this significant miniaturization job the pump makers turned to Aetna for assistance in "shrinking" the all-important anti-friction bearing units. You see the result here: one special, space-conserving Aetna thrust bearing tailored to do the job that formerly required two conventional-size angular contact bearings.

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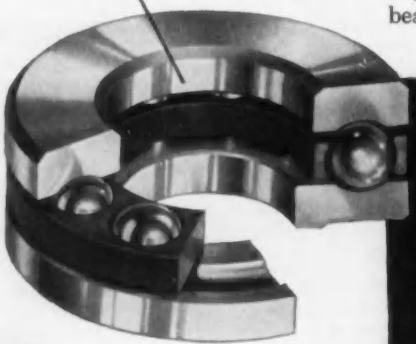
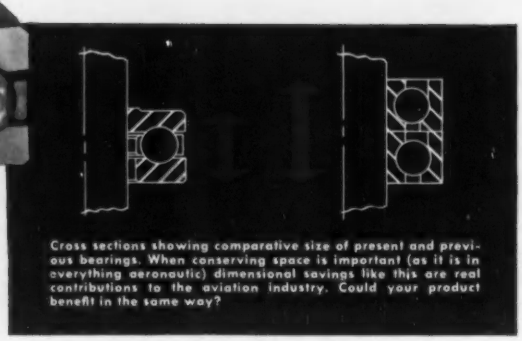
We invite you to use that wealth of specialized engineering knowledge whenever you have a ball bearing, roller bearing or precision parts problem.





Cross sections showing comparative size of present and previous bearings. When conserving space is important (as it is in everything aeronautic) dimensional savings like this are real contributions to the aviation industry. Could your product benefit in the same way?

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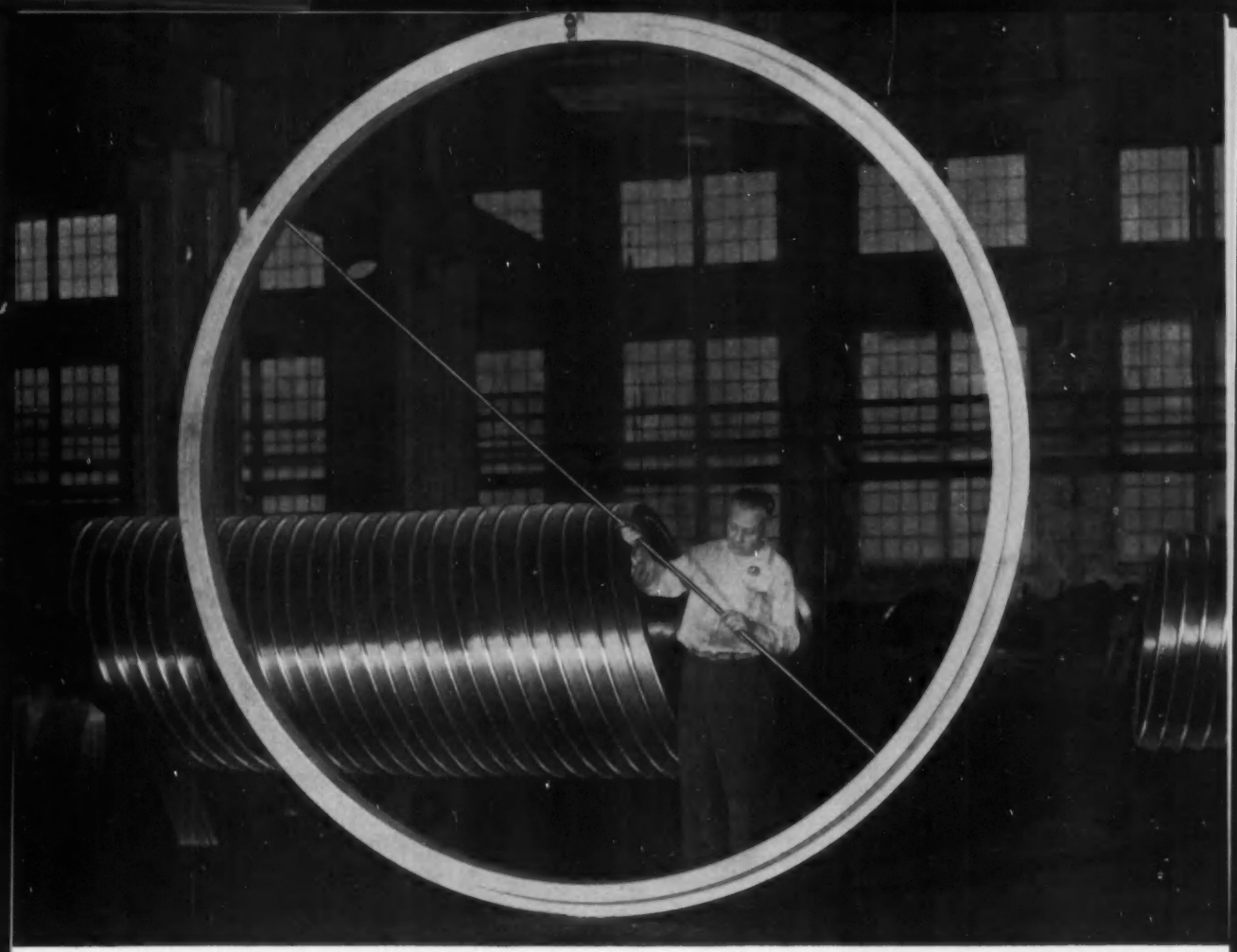

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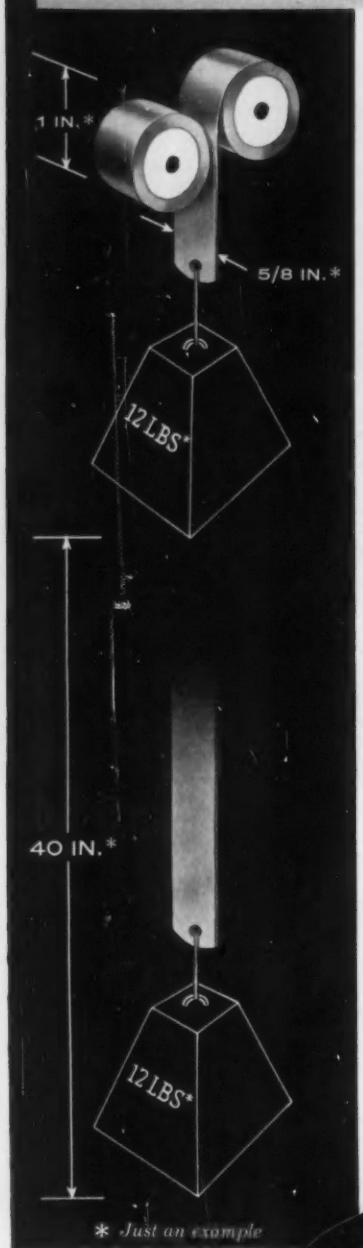
BALANCE IT *with a* NEG'ATOR® *constant-force spring*



* *Just an example*

NEG'ATOR is the name of a new kind of spring—the coiled-band spring that extends many times its original size without the increasing force common to conventional springs.

One of the natural uses of the NEG'ATOR Spring is counterbalancing without mass—vertically as illustrated, or horizontally. Using the NEG'ATOR Spring, the design engineer can eliminate dead weights or linkages and gain space, freedom of motion, reduced over-all weight, simplified assembly.

For example, each of the NEG'ATOR Extension Members used back-to-back in the illustration measures about 1 inch in diameter when coiled. They will counterbalance a 12 lb. weight over about 40 inches of travel. The only force required to move the weight is that required to overcome friction in the mechanism. There is no intercoil friction in the NEG'ATOR Spring.

NEG'ATOR Springs in extension or motor form are versatile in counterbalancing functions—are now being used to balance light tank floats in sensitive liquid-level indicators and fire doors and other heavy equipment. Extensions range to over 20 feet.

Used as an extension spring, a motor, band, clamp, or clip—this revolutionary new *constant-force* component upsets all previous spring principles, opens a whole new field of mechanical design by doing what springs have never done before.

These and other functions of Hunter NEG'ATOR constant-force springs are described in Bulletin 310N, "The Story of the NEG'ATOR Spring." Send for a copy.

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It's extra efficient, too, having only one air gap in the magnetic assembly. By spring-holding the armature rigidly in place, and using cross-bar contacts, all alignment problems are eliminated. Insulation is inorganic, hence there is no gassing or bubbling.

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piled from the published literature by preference, when the work appears in this form, but also from unclassified reports of various institutions to government agencies, when the work is available only in this form. In the latter case, some of the investigations from which data were taken are, at the time of this review, still under contract.

The information available as of March 1953 relating to the constitution of 48 binary and 22 ternary titanium alloy systems, including crystal structures, is compiled and evaluated. Introductory sections on the significance of phase diagrams in general and on possible types of binary titanium phase diagrams are included. In an appendix, lattice parameter curves for terminal and intermediate solid solutions are presented.

Dictionary of Color Names

8 x 10½ in., 158 pp. Published by National Bureau of Standards, U. S. Dept. of Commerce, Washington 25, D. C. $2.

The end result of four years of research and study, this dictionary not only includes color names from the various fields of application but also relates all the names listed to a common, fundamental system of designation. It lists 7500 individual color names and defines them in simple, accurate terms that can be easily understood by persons working in different fields.

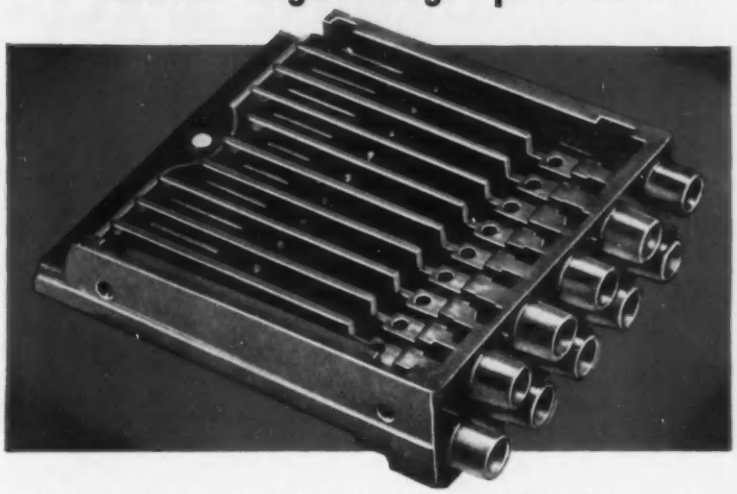
Listings are arranged in such a way as to permit anyone to translate rapidly and accurately from one color vocabulary to another. For example, the dictionary shows that griseo-viridis (from biology) is equivalent to serpentine (fashion) to mint green (mass market), and finally to light green (ISCC-NBS color designation). The terms used to designate colors represent a refinement of a method outlined originally by the Inter-Society Color Council and developed by the NBS in 1939. These color designations are precisely defined in terms of the standards of the Munsell color system, and the designation for any color may be read quickly and conveniently from color-name charts.

Circular 553 is made up of four

(Continued on page 463)

PRECISION PLASTIC MOLDING

to critical engineering specifications



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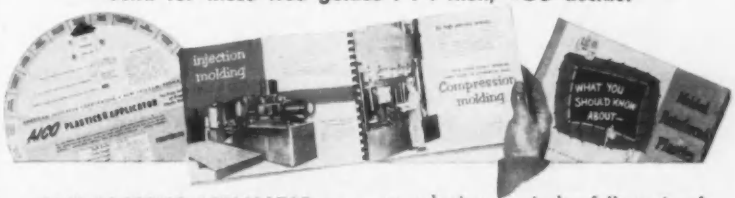

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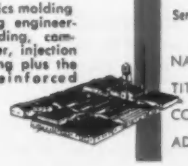

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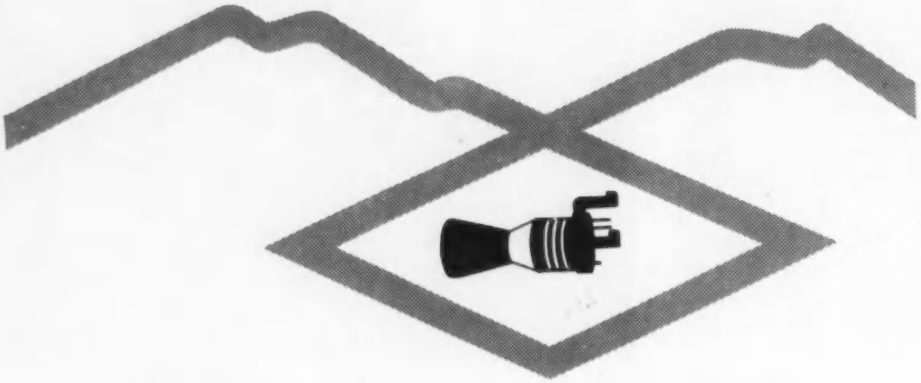

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General Mechanical Design of components of high speed rotating machinery such as gears, bearings, rotating seals, hydraulic drives and transmissions, turbines and pumps.

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Stress Analysts with experience on high speed turbomachinery. Background in gas turbine and jet engines preferred.

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BUILDERS OF POWER FOR OUTER SPACE

parts. The first part describes the techniques for determining the ISCC-NBS color designations for the colors of different types of samples. Next come the color-name charts from which the designations are obtained. The third part lists all of the color names studied in groups that are synonymous or nearly so; there are 267 groups, one for each of the ISCC-NBS color designations. The last part, which might be called the dictionary proper, is an alphabetical list of all of these color names, together with their designations in the ISCC-NBS system. With each color name is given a code letter indicative of the field in which it is used. After each ISCC-NBS designation defining a color name is a number referring to the section in the third part where all synonymous color names will be found.

Elevated-Temperature Properties of Carbon Steels

8½ x 11 *in.*, 63 *pp*, *paper bound. Published by the American Society For Testing Materials,* 1916 *Race St., Philadelphia* 3, *Pa.* $3.75.

This report is a graphical summary of the elevated-temperature strength data for carbon steels. It includes summary curves for tensile strength; 0.2 per cent offset yield strength; per cent elongation and reduction of area; stresses for rupture in 100, 1000, 10,000 and 100,000 hr; and stresses for creep rates of 0.0001 and 0.00001 per cent per hr (1 per cent in 10,000 and 100,000 hr).

This is one of a series of reports prepared under the auspices of the Data and Publications Panel of the ASTM-ASME Joint Committee on Effect of Temperature on the Properties of Metals.

The primary sources of data for this report were the laboratories engaged in the evaluation of metals for elevated-temperature service. However, to make this report more complete, data have been taken from trade bulletins and the published technical literature. Data sheets have been prepared from the data taken from these sources and are included with the data sheets contributed by the cooperating laboratories. The source of the data is given

(Continued on page 465)

Analyzing metal problems and prescribing cures is a job for specialists. Riverside metallurgists *are* specialists. They have the solution to almost any non-ferrous alloy problem you can name—whether it's tension or temper, fatigue resistance or surface finish.

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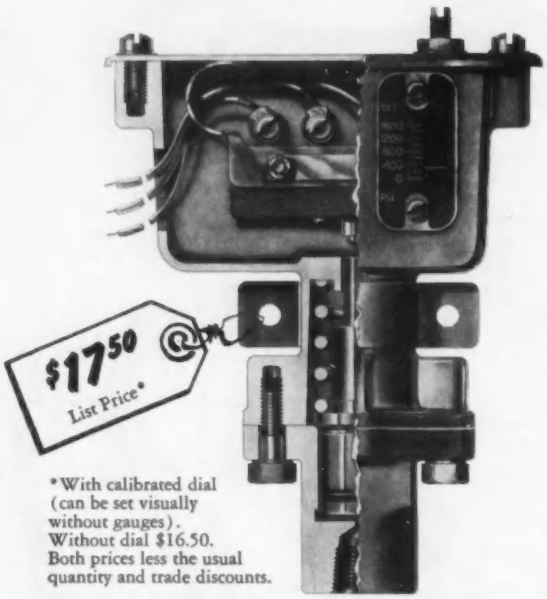

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RUGGEDNESS Can take surges— (High proof pressures) Continuous operation— (Millions of cycles) No sticking— (in dirty fluid)	 **LINKAGES & BEARINGS** Which wear quickly —(cause settings to drift and switch to fail).
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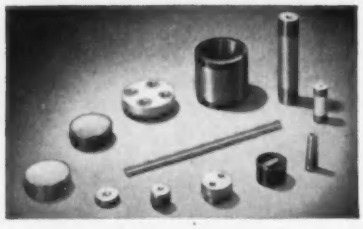

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on each data sheet. The following section headings were used for the various groups of data: killed carbon steel (0.12 to 0.17 C); killed carbon steel (0.18 to 0.24 C); ASTM A 201, Grade B, plate steel (0.24 C max); ASTM A 106, Grade B, pipe steel (0.30 C max); killed carbon steel (0.27 to 0.58 C); aluminum-killed steel; open steel (rimmed or capped); miscellaneous carbon steels.

Compact Heat Exchangers

W. M. Kays and A. L. London, *Professors of Mechanical Engineering, Stanford University.* 8½ x 11 *in.*, 156 *pp. Published by National Press, Palo Alto, Calif.* $5.

A treatment of compact heat transfer surfaces, including all of the types in use today. Types of surface dealt with are: 1) tube banks, including both circular and flattened tubes, with both inside and outside flow; 2) plate-fin surfaces, with a variety of fin types; 3) finned tube surfaces, with both circular and flat tubes and various types of fins; and 4) screen and sphere matrix surfaces. In all, basic heat transfer and flow friction test data are presented for a total of 88 surface configurations.

In addition, the authors consider a number of analytical solutions for abrupt contraction and expansion pressure-loss coefficients, laminar-flow heat transfer in circular and rectangular tubes, and the effects of temperature-dependent field properties on heat transfer and flow friction.

Standards of the Hydraulic Institute

8½ x 11 *in.*, 234 *pp. Published by Hydraulic Institute,* 122 *E.* 42 *St., New York* 17, *N. Y.* $4.75.

This tenth edition constitutes a complete revision and rearrangement of the format and the engineering data contained in earlier editions. Publication culminates over two years of intensive engineering study and research to insure that the contents constitute the most-up-to-date consensus of outstanding hydraulic pump engineers today.

The tenth edition has five sections.

(Continued on page 466)

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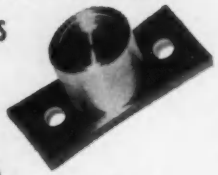

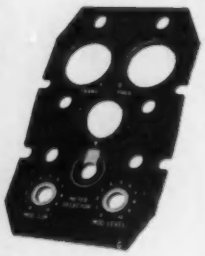

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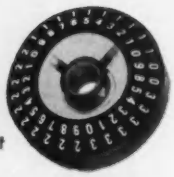

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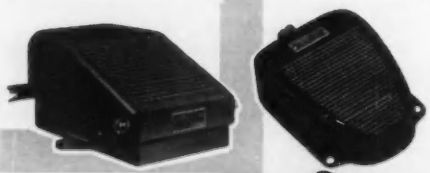

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The first section contains general information about the Institute and a brief history of the series of publications preceding this tenth edition.

Three sections are devoted, respectively, to the basic types of pumps, centrifugal, rotary and reciprocating. Each of these sections is arranged in a uniform manner to cover the classification, nomenclature, application, rating, testing and instructions for installation, operation and maintenance. Of special interest is the addition to the centrifugal pump section of a comprehensive listing of part names and definitions. Over 120 part names are included, covering the parts of double suction, multistage, end suction, close-coupled and axial flow pumps for both horizontal and vertical arrangements. Typical sectional drawings of these pump types are used to illustrate the nomenclature.

A fifth section is devoted to information on friction loss for water and for viscous liquids in pipes, valves and fittings; friction loss for paper stock in cast iron pipe; data on pipe dimensions; properties of water; viscosity of common liquids; together with a discussion and recommendations on materials of construction for pumping various liquids. The friction loss tables have been arranged for simplicity and convenience and specific examples are provided to show how they are to be used.

Switching Relay Design

R. L. Peek, Jr. and H. N. Wagar, *Technical Staff, Bell Telephone Laboratories, Inc.* 9¼ x 6¼ *in.*, 478 *pp. Published by D. Van Nostrand Co., Inc., 120 Alexander St., Princeton, N. J.* $9.50.

This book has evolved from texts for training courses in relay design given at the laboratories, and draws on accumulated experience in developing central office switching apparatus. The presentation serves both as an engineering text and as a reference book and design manual for relay engineers.

Switching relays are essential elements in a wide variety of automatic control apparatus, computing devices and communication systems. This book employs a fresh analytical ap-

(Continued on page 469)

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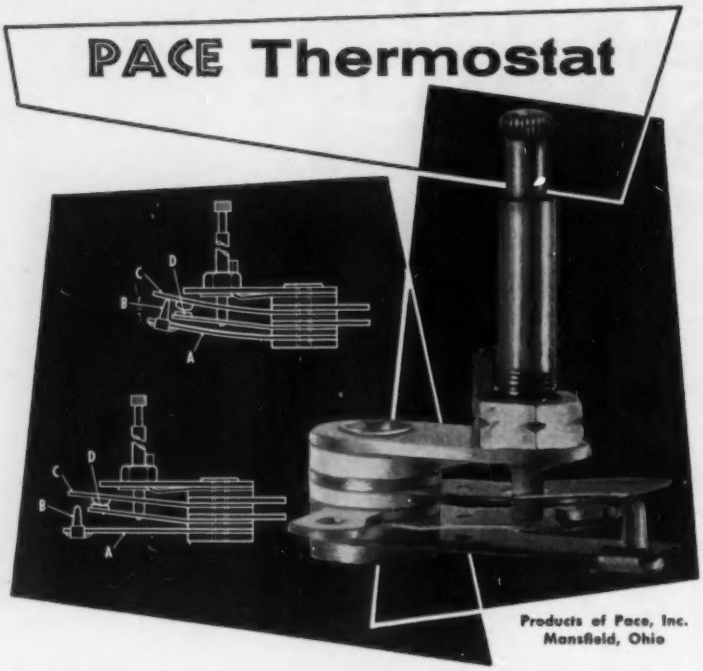

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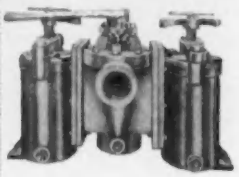

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proach in developing design relations of the mechanical contacting system and the actuating electromagnet of a switching relay, leading to an integrated treatment of dynamic performance. Procedures are given for evaluating characteristics of an existing relay and for predicting those of proposed design.

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Mechanical requirements of electrical contacts are reviewed, and procedures developed for designing contact springs and actuating members. An analysis of force-deflection and vibratory characteristics of spring systems and relay structures is given. These topics include methods of measuring parameters determining performance, means for estimating them, and optimum choice of parameters.

A Survey of High-Speed Printers for Digital-Computer Output

PB 111615, 8 x 10½ in., 18 pp, paperbound; available from United States Dept. of Commerce, Office of Technical Services, Washington 25, D. C. $0.50.

Current and anticipated applications of automatic digital computers require the printing of computer output at high speeds comparable with the speed of generation of output. Electric typewriters, such as Teletype or Flexowriter equipment, have been satisfactory in many cases in the past. Where two or three times their speed is required, it has often been practical to use several of these machines in parallel.

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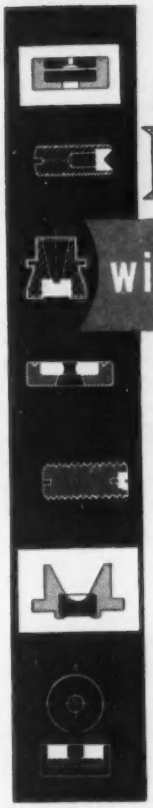
(Continued on page 470)



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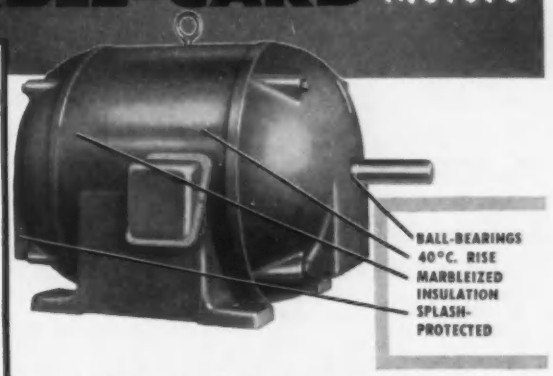

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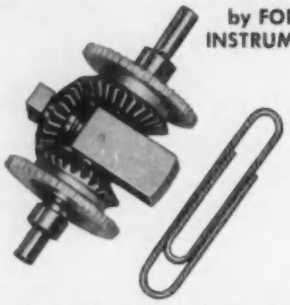

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be invested in a printing device; space available; and reliability required. Other more technical factors include: printer input required, whether alphameric or numeric characters are needed, printing format and form control, legibility and number of duplicate copies required, and use of low-cost paper.

This book presents a table and detailed characteristics of various mechanical, electrical, and electronic printers. It is intended to make possible the comparison of high-speed printers with regard to their suitability from the point of view of the foregoing considerations. It would be appreciated if any printer activities not included in this tabulation were called to the attention of the authors.

Research in Nonlinear Mechanics As Applied to Servomechanisms

PB 111584, 8¼ x 10¾, 148 *pp, paperbound. Available from U. S. Dept. of Commerce, Office of Technical Services, Washington* 25, *D. C.* $3.75.

The application of nonlinear mechanics to the field of servomechanisms and the development of specific applications is described. The feasibility of combined linear and "on-off" operation for both instrument servos and those having a control motor of hp ratings as great as ½ is proved. The switching criterion for higher order systems is developed. Network synthesis procedures are applied to the synthesis of a continuous controller to replace the discontinuous controller used in the dual mode system. Circuitry development includes evaluation of germanium diodes to be used in demodulators for servo work as well as other types of demodulators.

Handling and Testing Oil Hydraulic Drives and Controls

A. Dürr *and* O. Wachter, *Nürtingen/Württ.* 6 x 9 *in., 54 pp. Published by Springer-Verlag, Berlin* W. 35, *Germany. DM* 3.60.

Mr. Dürr, one of the authors of this treatise, is known to Product Engineering readers for his articles which appeared in the December 1955 and

(Continued on page 473)

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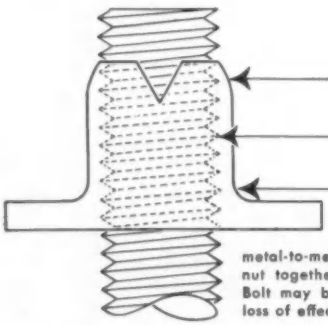
It is a one-piece, self-contained unit in which the self-locking device is an integral part of the design. No non-metallic materials or stamped parts are used so that the V-lock Teenut is not affected by heat or oils and has high tensile strength.

As the V-lock Teenut does not rely on base load to obtain its friction grip, it may also be used as a stop nut. (Indentations in base flange are welding bosses).



Bolt spins freely into nut until it reaches gripping area. Then, spring action creates strong, metal-to-metal wedging force, locking threads of bolt and nut together to make assembly virtually vibration-proof. Bolt may be removed and replaced many times without loss of effectiveness in nut.

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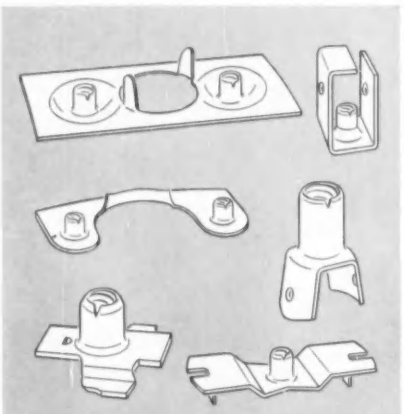

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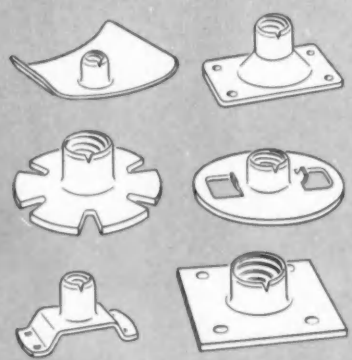
V-lock Teenuts can be engineered in various shapes and sizes to suit customer's specifications. Can be manufactured *in volume*... in brass, bronze, stainless steel, aluminum, etc.... with unified screw threads, class 2B, in both coarse and fine thread series. Finishes: zinc, cadmium, chrome, parkerized, etc. to customer's specifications.



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January 1956 numbers on the subject of hydraulics.

For anyone who can read technical German this is an interesting and informative treatise. In just 54 pages, the authors cover the basic fundamentals of hydraulic circuits. Even those who are unable to read the language glibly will get much out of the diagrams and charts.

One interesting table is a tabulation of twelve common breakdowns or troubles, giving the probable causes and also the steps to be taken to correct them. The booklet ends with a bibliographic list of 36 published books and articles on hydraulics.

Powder Metallurgy

6 x 9½ in., paper-bound, 309 pp. Published by Organisation for European Economic Cooperation, 2002 P St., N.W., Washington 6, D. C. $3.

The Powder Metallurgy Mission of the OEEC is comprised of 28 members representing seven European countries: Belgium, Denmark, France, Germany, Italy, Netherlands, United Kingdom. In view of the wide scope of the subject of powder metallurgy, the mission was organized into the following four groups based upon technical interest:

Group I—Electrical and magnetic materials: hard and soft cores, magnets.

Group II—Hard metals: tungsten and cobalt powders, single and mixed carbides.

Group III—Refractory materials: a) tungsten (wire manufacture) cermets; b) semi-rare metals: titanium, zirconium.

Group IV—Engineering powders and structural parts: a) iron, copper, bronze, stainless steel and aluminum powders; b) dense steel and nonferrous parts, bearings, friction linings.

During the tour of just over five weeks commencing Oct. 1, 1953, 43 visits were made to manufacturing plants, university and central research establishments. The entire mission took part in the 35th National Metal Congress and Exposition held in Cleveland, Ohio, and sponsored by the ASM, AWS, Institute of Metals Div. of the AIME, and the Society for Non-destructive Testing.

This is the final report of the Powder Metallurgy Mission.

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As you can see, the Hoke bar stock valve will contribute ease of operation, low maintenance cost and neat appearance to your equipment—hydraulic, pneumatic, instrument panel or test stand. It's available from stock in a wide range of sizes (⅛" to½" pipe) and materials (carbon, chrome or stainless steel and brass) . . . panel mounting, too if you need it. We'd like to send you our Bulletin.

P.S. We've just published a new wall chart on Hoke valves with valuable information on valve sizing and corrosion resistance. May we send you one?

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Fluid Control Specialists
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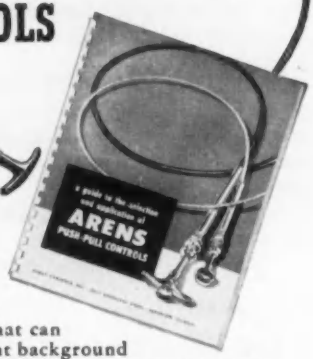

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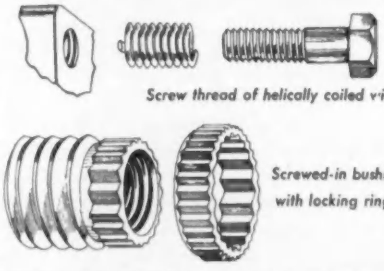
Light metals design tips



Use of screwed-in inserts increases design possibilities of magnesium

Use of screwed-in inserts is another development which makes magnesium suitable for an ever widening range of product uses. Here are a few basic facts about the types of screwed-in inserts shown above.

Screw thread of helically coiled wire—This coil type of insert is a thread lining made up of a precision shaped helical coil of spring wire used between the tapped hole and the mating bolts. For best results, coil inserts should be inserted to a depth of 2½ times the diameter when using heat-treated steel bolts. For mild steel bolts, a depth of 1½ times the diameter is suggested.

Screwed-in bushing with locking ring—Tubular in shape with threads cut in the exterior surface, this insert is installed by screwing into a threaded hole in the magnesium part. Used for bearings and bushings, it can also be threaded on the inside for the attachment of studs or bolts. The strength ratio of inserts to bolts or studs should be such that the bolts or studs fail in torsion instead of stripping the inside threads of the inserts.

Whatever your light metals problem, you can count on Magcoa engineering counsel and fabricating facilities. Write today for a free copy of our Magnesium Design Handbook.

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LIGHT METALS FABRICATION DIVISION • EAST CHICAGO 27, IND.

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OUR READERS SAY . . . . . .

Letters should be addressed to The Editor, *Product Engineering*, 330 West 42nd St., New York 36, N. Y.

Lubricants Containing Solids

To the Editor:

We have been impressed by and are much interested in the well-organized review in the Dec. 1955 *Product Engineering*, "Comparison of Six Lubrication Methods", by Dr. Beno Sternlicht of the General Electric Co. In Section Four (Oil-Mist Lubrication), your readers might be misled, though, by Dr. Sternlicht's statement: "Compounded oils containing graphite —or any other solids—are not practical. These solids separate from the oil and cause mist lubrication failure."

Actually, graphite in colloidal form is used successfully in oil-bearing systems for a diversity of applications, from bearings and conveyor-chain lubrication to coating of die-cavity surfaces in die-casting machines. We are sure Dr. Sternlicht did have poor experience with "graphite suspension in oil mist lubrication". Colloidal graphite, however, is a different breed of animal: by nature it remains in suspension—or else it is not colloidal. The particles are of colloidal dimensions, and in appropriate liquids they will not coagulate.

So far as oil-mist systems, specifically, are concerned, individual particles of colloidal graphite are much smaller than the individual droplets of air-borne oil and are carried along inside the tiny globules comprising the mist. There can be no separation of the colloidal particles out of the oil phase in this micro-system, and until the fog "condenses" on bearings or die faces the colloidal graphite does not come in contact with solid surfaces.

—D. G. WEAVER
Port Huron, Mich.

Ed—Below are Dr. Sternlicht's comments on Mr. Weaver's letter. "In answer to Mr. Weaver's letter, I wish

(Continued on page 477)

Our special business is specials . . . special fabricated wire cloth parts made to your specifications. We save you time, we save you overhead, we save you production worries. And, you get a better part at a lower cost.

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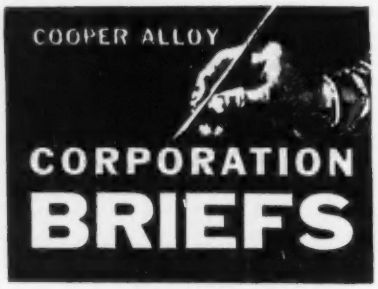

• Edited by GEORGE BLACK

VALVE CLINICS

In spite of our belief that the Cooper Alloy stainless steel valve offers the best in design and operating features, we take it to school regularly. This "school" consists of continual study by field engineers, design engineers and by industry itself subjecting it to intensive examination and reporting their findings at organized Valve Clinics.

Cooper Alloy Valve Clinics have been held in dozens of leading plants, including Dow, DuPont, Mathieson, Celanese, Pfizer and many others. Arrangements for such a clinic in your own plant may be made through our Public Relations Division.

"FLEX-ALLOY" STAINLESS PUMP

A new line of stainless steel rotory pumps for corrosive solutions, abrasive slurries and fluids which must be kept free from contamination has just been announced by our Vanton Pump & Equipment Division. Called "Flex-Alloy" these new pumps in type 304 or 316 stainless (other alloys on request) incorporate the same no-stuffing box, no-shaft seals, no-gasket features of the popular "flex-i-liner" plastic pump series. Full details are given in Bulletin VP561.

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On October 14, 1947, the Bell X-1 made history by flashing through the skies faster than sound. Cooper Alloy is proud to have been teamed with the Glasby Company in helping Bell Aircraft carve its notch in history by furnishing the 30" diameter, 3" wall stainless steel sphere required for handling the liquid nitrogen.

COOPER ALLOY
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to state that in general I had poor experience with graphite suspension in oil-mist lubrication applications. It is quite true that satisfactory performance will depend to a large extent upon how well the colloidal graphite can remain in suspension, the size of the particles, and whether or not the graphite particles are resistant to coagulation."

"In applications where the lubricant path is complicated and, therefore, where there is a pressure drop, the tendency is for the graphite particle to separate. Thus, a buildup of graphite in one area is often produced which eventually may result in lubrication failure. It is true that colloidal graphite increases the heat transfer coefficient, but it is the oil and the air that take away the heat."

"The author is not criticizing the product made by Acheson Colloids Co. or any other company, for if the product is stable and does not separate, it should serve the useful function of reducing coefficient of friction and thus heat generation."

Correction

To the Editor:

I wish to inform you that there were errors in my article, "Comparison of Six Lubrication Methods", in the Dec. 1955 issue. I feel they should be corrected. Below the errors are listed:

1) Page 183, in the list of symbols
   m — clearance ratio; units should be in./in. instead of in./lb.
   F — size factor; final term was omitted, should read

$$\left(\frac{D_o + D_i}{2}\right)_W$$

2) Page 188, in the formula near the end of the text, brackets were omitted from the term following

$$(1.093)\ 10^{-4}N$$

DR. BENO STERNLICHT
Schenectady, N. Y.

More Opinions on Germany and the Nazis

To the Editor:

I wish to thank you for the reply given to Mr. Runken's letter regarding your article in the January issue, "Germany's Amazing Comeback." I was born in Germany and became a

(Continued on page 479)

MIDLAND WELDING NUTS ...Make Tough Jobs Easy!

SAVE TIME!
SAVE TROUBLE!
SAVE MONEY!

If you've got a product involving metal fabricating, fastening or assembling, chances are you can use Midland Welding Nuts to big advantage.

They come in all sizes for every-sized job. Welded to the part or parts concerned, they don't have to be held while bolts are turned into them. Thus one man can often do the work of two.

And they're indispensable when it comes to those tucked away, hard-to-get-at places. Welded in advance to those inside spots where it is difficult—or *impossible*—for hands or tools to reach, Midland Welding Nuts hold fast while bolts are turned into them.

If you're a designer, you'll want to know about these time and labor-savers, too. Midland Welding Nuts will solve and simplify many of *your* problems, too.

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U. S. citizen in 1949. A trip to Germany in 1954 convinced me that I would not like to return there to live. The mind that made Hitler possible has not changed much.

—CHARLES S. REHN
New York, N. Y.

To the Editor:

Having spent the first 20 years of my life (until 1937) in Germany, and almost 20 years in this country, I feel entitled to comment on your exchange of letters with Mr. G. Runken, in the March issue of your magazine:

I wish to congratulate you on your objective and moderate presentation of the case against Mr. Runken. I am glad that you left no doubt as to your position. —PAUL ROSENTHAL
Buffalo, N. Y.

To the Editor:

With reference to your reply to the letter from Gerd Runken, March, 1956, *Product Engineering*, I certainly agree with everything you said, in both your reply and the original article. However, though we all admire a plucky comeback, I am not especially pleased to see our old enemies and allies beating us at our own game—mass production and bold design. It is time for us to again take the lead.

I believe that flexible "job-shop" automation is the answer. Not Detroit-brand automation. Machines and control systems can no longer be designed separately.

—GEORGE H. AMBER
Detroit, Mich.

Ed—I am in hearty agreement with everything you say. I just want to reemphasize your statement that a flexible "job-shop" approach is the answer.

Decimal Dimensions

To the Editor:

One of the articles appearing in the Oct. issue of *Product Engineering* was "Gage Numbers Vs. Decimal Dimensions", by I. V. Williams of Bell Telephone Laboratories.

Several of the committees of the American Gas Association, that prepare requirements for construction and performance of gas burning appli-

(Continued on page 481)

LATEST PE EXTRUSION FOR FELT & TARRANT MFG. CO. CUTS COSTS 50%

before
L-shaped strip welded to base
Original steel part made of two pieces — main base and clip retainer. Required blanking, forming (3 operations), milling, welding, finishing, assembly.
after
New one-piece 6063 T-5 extruded aluminum base, including clip retaining channel, eliminates 6 operations. Only requires 4 drilled holes and riveting separate locator pieces to each end.
CASE STUDY 103
Clip strip for Comptometer Accessory Board used to hold accounting forms.

Here is another example of how PE Extrusioneering helps cut costs and improves product quality — this time for Felt & Tarrant Mfg. Co., world famous manufacturers of adding-calculating machines. By designing the aluminum extrusion illustrated above, 6 manufacturing operations were eliminated, (see sketches), assembly simplified, and inventory problems reduced. Extrusions are now ordered in 10' lengths and cut to size as required. These changes effected a 50% reduction in part costs.

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For helpful data, write for free copies of PE news covering case study reports on cost cutting extrusion applications.

Perhaps like Felt & Tarrant you can use PE extrusioneering service to an advantage in reducing costs. Ask a PE Engineer to work with you and help you develop new ideas to solve specific problems. You can depend upon their experience and technical knowledge to save you time and trouble. Your inquiry will receive fast, individual attention. PE is a non-competitive mill service. We manufacture extrusions only.

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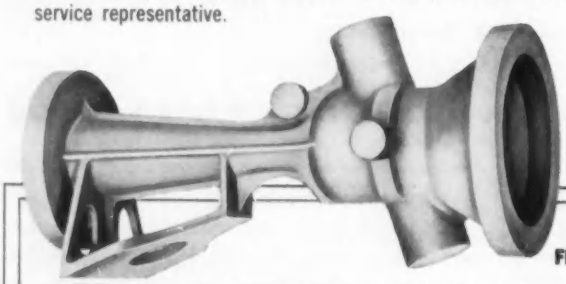
CHOOSE THE ALLOY YOU WANT—Investment Castings are produced in any of the ferrous or non-ferrous alloys, including magnesium.

USE THE PROCESS WISELY—Give full consideration to weight, dimensions, tolerances and surface finishes when designing for Investment Casting. Take full advantage of the economies inherent in the process.

CONSULT ARWOOD ENGINEERS—Arwood casting engineers will gladly consult with you on your design and production problems, helping you translate them into finished products. Write for the name of your nearest ARWOOD sales and service representative.



DESIGN FLEXIBILITY

Parts similar to this stainless steel valve body for an air flow controller often require several changes before design is finalized. Due to the relatively low cost of dies and die changes, the investment casting process has proven an inexpensive and flexible method.

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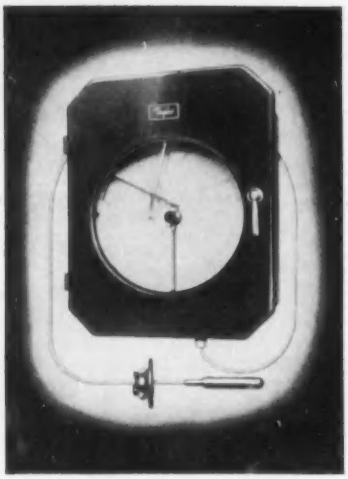

Courtesy Taylor Instrument Companies

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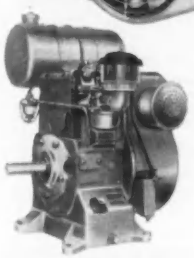

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Lightweight, air-cooled Onan Diesel engine

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Two-cylinder, opposed. 15 H.P. at 2300 R.P.M. 4-cycle. Solid injection, full Diesel. Electric starting. 12-volt generator. Full pressure lubrication.

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ances, have modified these requirements to eliminate gage numbers and specify decimal thicknesses. Naturally there have been some objections to this but I believe that in time all committees will revise requirements under their jurisdiction to specify decimal thicknesses. For these particular requirements an absolute minimum thickness is given and any thickness above that stated would be acceptable.

Mr. Williams' article should be of considerable interest to the members of the various committees of our organization, approximately 250 men, and I would like very much to have your permission to photostat this article and distribute it to these committee members. In the past I have taken the liberty of mentioning your editorials relative to decimal thicknesses to several of the men that have been interested in the subject and also during some of the committee meetings.

—R. E. CRAMER
Cleveland, Ohio

Ed—It was with pleasure that permission was granted to Mr. Cramer for the preparation of copies of the Williams article.

Bibliography of Mechanisms

To the Editor:

I take pleasure in announcing the first issue of a new publishing venture, a bibliography on mechanisms which will be published monthly. For more than ten years I have collected notes on articles on mechanisms and related subjects found in books, theses, papers and in various technical journals, among them your own. As I was not able to interest a publishing house on this project, I recently decided to publish this material myself.

The purpose and aims are outlined on the cover pages and I should be glad if you would kindly announce this bibliography in your magazine. Sample copies will be supplied to your readers without charge.

—PAUL GRODZINSKI
41 Tudor Close Belsize Ave.
London NW 3, England

Ed—It is suggested that those readers interested in Mr. Grodzinski's bibliography write him directly, at the above address.

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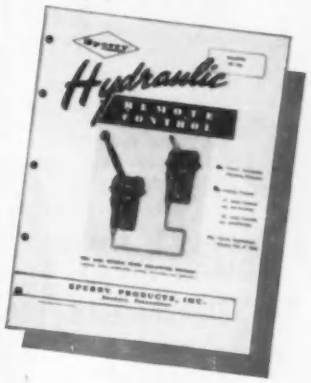
for hydraulic, mechanical and electrical applications



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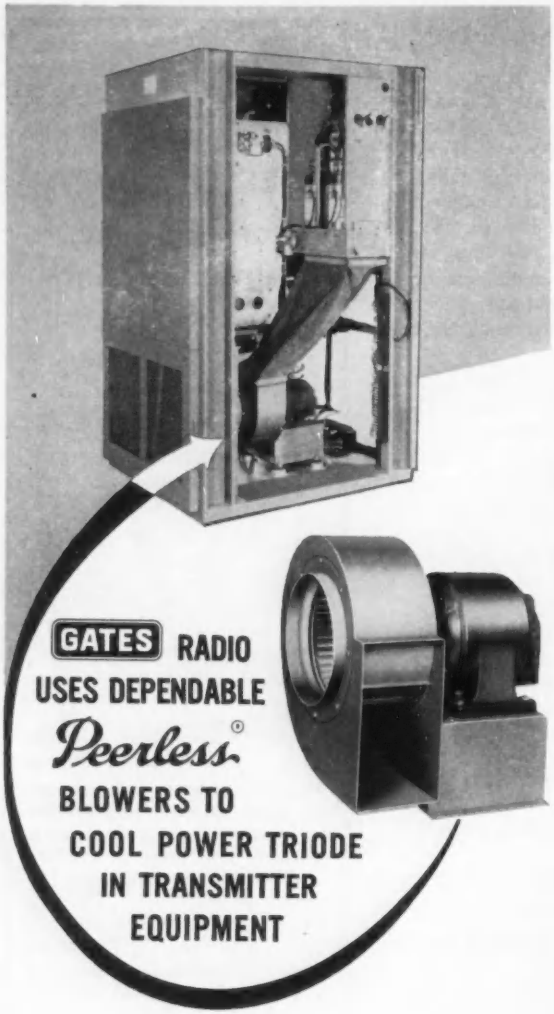

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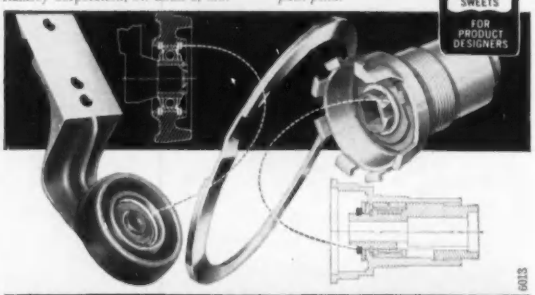

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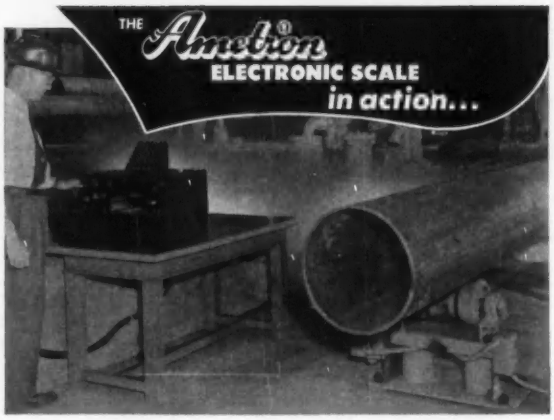

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PRESS PREVIEWS

L.O.F. Glass Fibers To Step Up Insulation Production

Through recent lease of a 15,000 sq ft building and lot, the L.O.F. Glass Fibers Company has more than doubled its Burbank, Calif., plant facilities. These properties adjoin the original Burbank plant.

The Burbank plant supplies insulation components to the aviation industry. The facilities at Burbank manufacture thermal and acoustical insulation blankets and shrouds, used by the makers of commercial and military aircraft. The lightweight and efficient insulating properties of glass fiber for aircraft, according to the company, have given design engineers a material that can be fabricated readily and meets critical weight specifications while protecting flying personnel and the airframe against heat, cold and sound. The blankets are made on multi-needle quilting machines.

The high temperature blankets and shrouds used on tailpipes and afterburner sections of high-speed jet aircraft are made of heat-resistant insulating material sandwiched between layers of light gauge stainless steel or inconel foil. These sandwich constructions are electrically welded. To do this job, a new, high-speed resistance welder, made by the Siaky Company of Chicago and the only one of its type, was recently installed in the Burbank plant.

Zinc Corrosion Control Described in Movie

A 16-mm sound and color motion picture, "Zinc Controls Corrosion" has been produced by The American Zinc Institute, Inc., national trade association for the zinc industry. Available for showing before agricultural, industrial, technical and educational groups, the new AZI film dramatically tells how zinc controls corrosion to

(Continued on page 485)

HANDYMAN'S DELIGHT! by Shopmaster

Shopmaster 8" Tilting Arbor Circle Saw, Model HS-56

with Sewall Gears for professional accuracy

Shopmaster's new 8" tilting arbor circle saw buzzes with features to excite the Do-it-yourselfer. This "workshop-in-itself" performs shaping, dadoing, sanding plus ripping and cross-cutting . . . all with professional accuracy thanks to precision machined internal parts and gears made to Shopmaster's exacting specifications.

Sewall's complete gear service can help you . . . call us!

Custom-made gears

Made-to-order sprockets

Special gear racks—to order

Standard gear racks—in stock

Our reputation is based on quality, service and price. If you're like our regular customers you're vitally concerned with these three factors when you buy gears. (1) Gears must meet your specifications exactly, in strict accordance with your prints. (2) Gears must be delivered as scheduled. (3) The price must be reasonable. Sewall gears are made by men who are fussy about specifications. We have a wide range of late-model machine tools, inspection instruments and checking equipment regularly serving customers across the nation. Our large modern plant is handy to rail, truck and air transportation.

Let us quote on your specifications!

Write for New 4-page Bulletin

The Sewall Story . . . richly illustrated with in-plant photos . . . includes listing of capacities and facilities.

SEWALL GEARS

E. B. SEWALL MANUFACTURING COMPANY

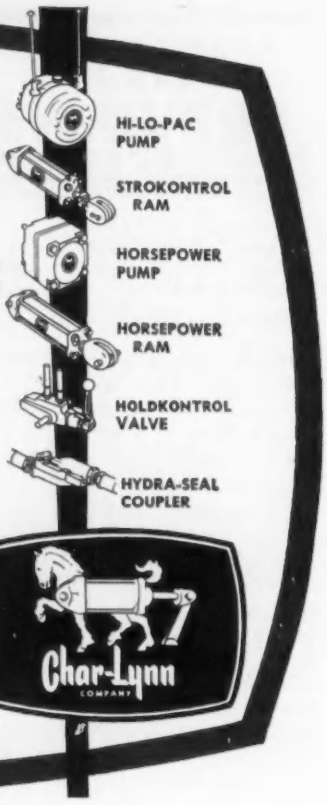
704 Glendale Street, St. Paul 14, Minn. Midway 5-7721

NEW! Char-Lynn "Live-Power" HYDRAULIC PUMP

The Char-Lynn Model 400 Pump is designed for front mounting, thereby freeing the P.T.O. . . . Gives LIVE POWER for all implement operations. There is no need for repetitious clutch operation, no intermittent power supply.

A compact powerhouse of hydraulic action. The **400** is the smallest in outside dimensions (4½" square) of any pump with equal capacity.

MATERIAL:	Die Cast Aluminum Body Hardened Steel Precision Gears (*Gerotor Mechanism*)
MAXIMUM PRESSURE:	1500 psi Relief
MAXIMUM SPEED:	2400 rpm
DELIVERY:	10 gpm at 1750 rpm
SHAFT:	⅞" diameter ¾₁₆" woodruff key
MOUNTING:	Directly on studs. Can be reversed for mounting off back of pump.
OIL PORTS:	¾" NPT tapped
SHIPPING WT.:	11 pounds



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CHAR-LYNN COMPANY

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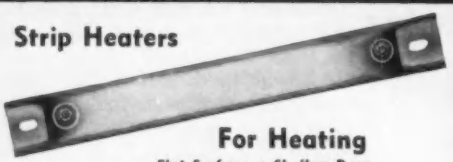
Hydraulic Horsepower To Serve You Better

VULCAN
ELECTRIC HEATING UNITS

Strip Heaters



For Heating

Flat Surfaces • Shallow Pans
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RUGGED CONSTRUCTION

Rust-resisting sheath is of one-piece rectangular tubing, specially drawn to our specifications.

Heater coil, of nickel chromium wire, is insulated from the inner sheath wall with a refractory selected for best Terminal conduction and stability at elevated temperatures. Terminal screws are stainless steel, to ensure strength and avoid oxidation.

115 and 230 volts. Five terminal arrangements

Steel sheath (150 to 1250 watts) for temperatures up to 750° F max. High temperature sheath (250 to 1500 watts) for temperatures up to 1200° F max.

VULCAN ELECTRIC COMPANY

DANVERS 18, MASS.

By the makers of Vulcan Electric Heating Units, Soldering Tools, Solder Pots, Glue Pots, Branding Irons and Electric Heating Devices

See 8-page Vulcan catalog in Sweet's Product Design File for 1955.

TENSION CONTROL ON PAPER MILL ROLLS

Wagner Actuating system and brakes maintain easily adjusted uniform tension

Wagner Industrial Drag Brakes on the paper mill roll stand shown here, keep constant tension on the roll as paper is fed out to other machinery. Brakes are actuated by a Wagner control cylinder, which is operated by a hand wheel. A Wagner Type H Brake, of the type shown below, is used in this application.

For *your* specific applications, Wagner can furnish engineered kits with actuators, controls, tubing, fittings—everything required for complete installation. Your nearby Wagner field engineer will get you detailed specifications on a system for your particular application. Call him today.

Wagner Electric Corporation

6406 PLYMOUTH AVE., ST. LOUIS 14, MO. 156-1

lengthen life and how maintenance and replacement costs are minimized.

The 35-minute film presents the general mechanism of corrosion and describes methods for coating steel stock or products with zinc, with a survey of the various fields of usefulness for zinc-coated parts. "Zinc Controls Corrosion" also shows new continuous galvanizing lines, the hot dip galvanizing of large structural parts, and means of corrosion prevention such as cathodic protection, metallizing, sherardizing, and painting.

Bookings for "Zinc Controls Corrosion" are now being accepted at The American Zinc Institute, Inc., 60 East 42nd St., New York 17, N. Y. The new film is available for showing at no charge. Special booking forms can be had on request. "How Zinc Controls Corrosion" is the second of two 16-mm color and sound motion pictures recently made available by the American Zinc Institute, Inc., to interested parties. The first, released little more than a year ago, "Die Casting: How Else Would You Make It," may also be requested for showing.

Doehler-Jarvis Plans Larger Casting Capacity

An expansion program which will increase the annual capacity of the die casting facilities of the Doehler-Jarvis Division of National Lead Company by 20 million lb of aluminum and 15 million lb of zinc has been announced by Joseph A. Martino, president of National Lead. The program will involve the extension of existing buildings, the addition of new die casting machines, and provision of related electrical and hydraulic facilities. Expansion will take place at plants in Toledo, Ohio; Pottstown, Pennsylvania; Grand Rapids, Michigan, and at Barber Die Casting Co., Ltd., in Hamilton, Ontario, subsidiary of National Lead. Completion is scheduled for the middle of this year.

At the Toledo plant at 1945 Smead Avenue, additional aluminum die casting machines will be installed, increasing metal consumption by about 10 million lb per year. Also, the 25-cycle electrical current system and a 5000 kwa sub-station is being set up to cover future demands of the expanded production program. The new

(Continued on page 487)

by Parker

In Automation . . . Instrumentation . . . Supersonic Aircraft—wherever true automatic control is needed, 3 dimensional cams by Parker can literally make machinery "think". By controlling relative motions through geometric and non-geometric curves, these mechanical "brains" take virtually any two variables and extract the correct functional resultant in a split second. Parker machines ultra precision into thousands of specified cam stations *and to all intermediate points between stations!* For prototype, master or production runs of 3 dimensional cams—you devise the problem, Parker will engineer and machine the answer!

Send today for "3 Dimensional Cams"—technical data on Parker's ability to make superhuman functions automatic.

THE PARKER STAMP WORKS, INC.
CAM DIVISION
FRANKLIN AVENUE • HARTFORD, CONNECTICUT

Faced with a fastening problem?

Specify CAMLOC® QUARTER-TURN FASTENERS

They cost less to install and fewer do the job . . . better!

Wherever quick access on panels, doors and covers is imperative, Camloc ¼-turn fasteners save precious time and labor . . . in both installation and future operation. Absolutely vibration-proof, Camloc ¼-turn fasteners open fast . . . close fast . . . hold fast! Because fewer fasteners are required to do any given job, Camloc ¼-turn fasteners *cost less* to use.

If you have a fastener problem, we suggest you inquire during early design phases of your product so that we may assist you in developing an efficient structure-fastener combination.

ONLY A QUARTER-TURN WITH SCREWDRIVER OR WING-HEAD ASSURES QUICK, POSITIVE LOCKING ACTION

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Storehouse of well-organized facts, data, and procedures on every phase of metal casting process. A guide to best foundry practices, it gives clear, detailed methods for successful patternmaking, molding, coring, sand conditioning, melting, pouring, cleaning, and inspection. Covers types of casting metals and their properties, with data on their strength, limits, characteristics, etc. **By R. W. Heine, Assoc. Prof., and P. C. Rosenthal, Prof., Dept. of Mining and Metal'g., Univ. of Wisconsin. 639 pp., 6 x 9, 400 illus., $7.50.**

ENGINEERING METALLURGY

A guide to the whys and hows of metal behavior — practical yet soundly based on theory, and especially stressing the unity of all metal behavior. Sources of metals, their fabrication and properties, the interrelation of these factors, and the unique qualities of individual metals are described. **By L. F. Mondolfo, Prof. of Metallurgical Eng'r'g, Ill. Inst. of Tech., and O. Zmeskal, Dept. of Mech. Eng'r'g, U. of Fla. 382 pp., 6x9, 204 illus., $8.00.**

DYNAMICS OF MACHINERY

A helpful mathematical approach to dynamic force analysis for use in solving mechanical engineering problems. In addition to providing a theoretical treatment of dynamics and kinematics, the book demonstrates practical application of such techniques as vector notation, Fourier series and harmonic analysis, and the Laplace transform. **By J. B. Hartman, Prof. of Mechanical Eng'r'g, Lehigh U. 283 pp., 6x9, 154 illus., $7.50.**

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Just Out! Covers principles, operation, and design of analogue computers. Gives descriptions of components, computing elements, and procedures for arranging problems for analogue computation. Emphasizes the effects of imperfections in computing elements and means for reducing these factors. **By C. A. A. Wass, Supt of Dynamic Analysis Division, Royal Aircraft Establishment, Farnborough, England. 237 pp., 149 illus. $6.50.**

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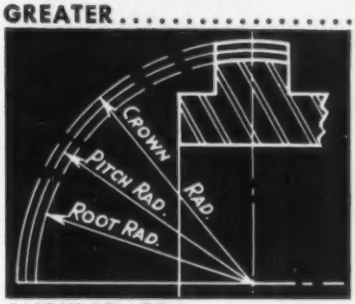
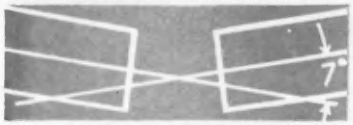
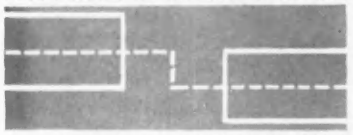
PERFECT SPHERICAL TOOTH FORMATION PERMITS GREATER.....



ANGULAR OR.....



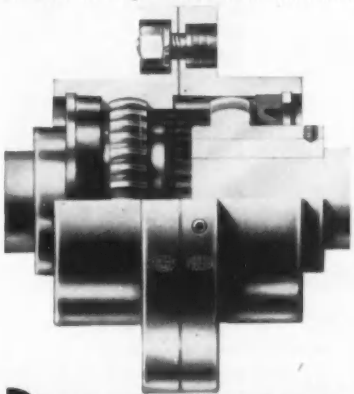
.....LINEAR MISALIGNMENT



The Philadelphia SPHEREFLEX COUPLING features a Spherical cut tooth which allows a ball and socket action between mating teeth up to 14° angular misalignment—and due to this angular capacity, a much greater amount of parallel misalignment is possible, which varies directly as the pitch diameter of the gears. All this is accomplished by gearing having a minimum back-lash.

By using Sphereflex Couplings, you can eliminate excessive bearing loads and cyclical bending stresses, which are caused by misalignment between shafts.

Send for Catalog C-560, and be convinced.



PHILADELPHIA GEAR WORKS INCORPORATED

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BALTIMORE • CLEVELAND
Virginia Gear & Machine Corp., Lynchburg, Va.
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Established 1892

die-casting machines at the Toledo plant can handle aluminum castings up to 30 lb. Other casting machines will be added to produce automobile grilles and mouldings, large automatic transmission housings and other parts weighing up to 20 lb in aluminum or to 50 lb in zinc. Capacity at this plant will be increased by approximately 10 million lb of aluminum annually.

The Doehler-Jarvis Grand Rapids operation will increase die casting capacity by almost 100 per cent with installation of die casting machines in the new building space. The use of zinc in Grand Rapids will be increased by approximately 15 million lb per year. The Grand Rapids operations will be expanded in the fields of color-anodized aluminum stampings and forgings, and assembled products for the automotive and appliance industries.

A new alloying facility has been built at Pottstown plant No. 2 to permit more efficient metal recovery and utilization, and for more efficient supply of molten metal to the die casting machines. At Pottstown plant No. 1 a new 33,000-volt sub-station is being built to cover the additional demand for electrical current. Capacity of the painting department has been doubled at this location.

Barber Die Casting Co., Ltd. will install its first large die casting machine with capacity of 30 lb in aluminum and 50 lb in zinc under the expansion program to meet the growing demand for larger castings in Canada.

Worthington Unveils Welding Laboratory

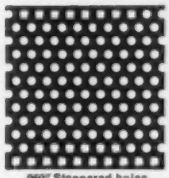
A new, fully equipped Welding Research Laboratory was opened recently at Worthington Corporation's Harrison, New Jersey, Division. Said to be one of the most complete research facilities of its kind, the laboratory is designed for application of advanced welding techniques for development and manufacture of company products.

The laboratory has more than 5000 sq ft of shop space. Facilities are available for fabricating and welding structures up to 10 tons and an automatic welding manipulator and tilting floor is conveniently located in a nearby

(Continued on page 489)

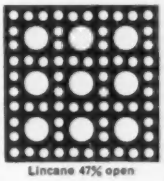
Perforated Materials for *Every* Application

Contact H & K for any perforated materials your product may require.



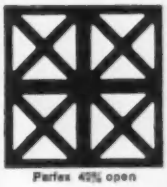
.060" Staggered holes. 126 holes per sq. in. 3/32" centers. 38% open.

We will be glad to work with you on your perforating problems.



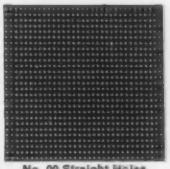
Lincane 47% open

Perforating all metals, Masonite, plywood, paper, cloth and plastic.



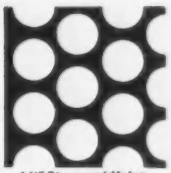
Perfex 42% open

Fill-in and mail coupon to office and warehouse nearest you.



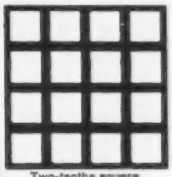
No. 00 Straight Holes 952 holes per sq. in. .022" diam. 30% open.

We have tools for perforating thousands of different patterns.



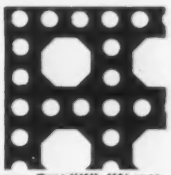
1/4" Staggered Holes. 5/16" centers. .25" diam. 58% open.

See our catalog in Sweet's Product Design File.



Two-tenths square, 64% open.

Round holes, square holes, slots, ornamental patterns, oblong holes, oval holes.



Cana "41" 41% open.

THE **Harrington & King** PERFORATING CO.

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Please send me—

- ☐ GENERAL CATALOG NO. 62
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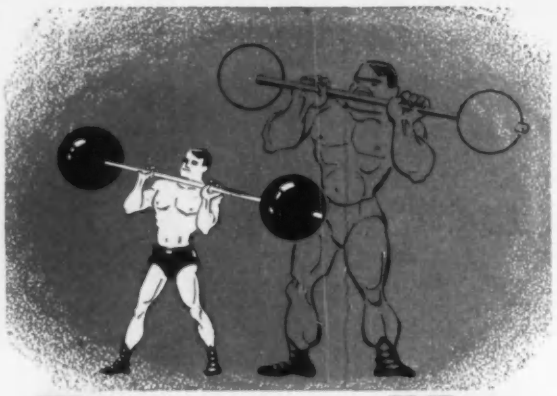


Power-Up your equipment the "Beefless" way

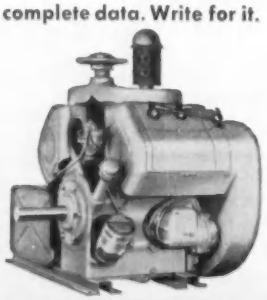
You don't need "beefy" bulk to get brawn . . . nor *size* to insure stamina. Built for the work you want them to do, *sized* to fit your equipment most readily, Wisconsin Heavy-Duty Air-Cooled Engines offer a variety of design and performance advantages.

Every Wisconsin Engine from the smallest to the biggest has such features as tapered roller main bearings, forced lubrication, impulse-coupled rotary type high tension *outside* magneto . . . and the tight compactness provided by high capacity flywheel-fan AIR-COOLING, efficient from sub-zero to 140° F.

Every Wisconsin Engine (3 to 36 hp.) has the inbuilt "lug-ability" to slug it out in the roughest company . . . in construction service, railway-maintenance-of-way, irrigation and general farm service, on oil field utility units, truck refrigeration, materials handling or what have you!

In this performance, Wisconsin's advanced concept of heavy-duty engineering in a compact power package plays an important role in direct relation to the *design* and *operating* requirements of the original equipment builder.

Bulletin S-188 brings you complete data. Write for it.



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World's Largest Builders of Heavy-Duty Air-Cooled Engines
MILWAUKEE 46, WISCONSIN

SOLENOID OPERATED AIR VALVES

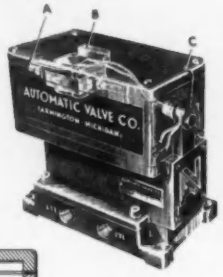
designed to

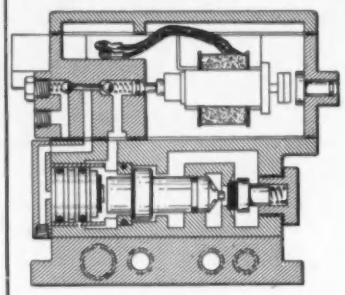
J.I.C.

standards

1/4" - 3/8" - 1/2" - 3/4"

4-Way—Model 441





FEATURES

A—Manual Operating Button

B—Water-tight and Dust-tight Solenoid Enclosure with built-in Electrical Junction Box.

C—Cover chained to Body

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Bendix Electric Fuel Pump performs better . . . lasts longer!*

1. Performance-proven
2. Longer Life • No Pressure "Droop"
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Learn more about this new and improved fuel pump. Write for descriptive folder and specifications.

ECLIPSE MACHINE DIVISION ELMIRA N. Y.

Bendix AVIATION CORPORATION

*REG. U. S. PAT. OFF.

shop. The table for this machine is 18 by 33 ft and weighs 65,000 lbs, one of the largest installations of its type in the country.

This facility will also aid training programs for welding operators, supervisors and technicians.

Grace Begins Construction of Polyethylene Plant

Construction has begun on the W. R. Grace & Co. multimillion dollar polyethylene plant near Baton Rouge for the Polymer Chemicals Division. In a brief public ceremony at the plant site, the international chemical, financial, and shipping firm was officially welcomed to the State by Governor Robert F. Kennon and Senator Russell B. Long.

The Polymer Chemicals Division is a new division of W. R. Grace & Co. Its formation was announced today from New York by Hugh S. Ferguson, Executive Vice President for the chemical group of Grace. At the same time, Mr. Miller was named to head the new division, and Elwyn E. Winne has been made Vice President.

Mr. Ferguson also announced the realignment of the Dewey and Almy Chemical Company Division (Cambridge, Mass.) into three divisions of the parent company: Dewey and Almy Overseas Company Division; CRYOVAC Company Division; and a third division to operate under the historic name. Mr. Ferguson was President of the Cambridge firm prior to its merger with Grace in 1954 and until his election to the Grace post.

National Gypsum To Work Canadian Mine

Canadian Premier Maurice L. Duplessis and Board Chairman Melvin H. Baker of National Gypsum Co. of Buffalo, N. Y., in a joint announcement have revealed that development work is scheduled to begin on a new multi-million dollar asbestos mine and plant at Thetford Mines, 75 miles southwest of Quebec. The new mine and plant will supply asbestos fibre to three National Gypsum asbestos-cement plants at Millington, N. J., St. Louis, Mo., and New Orleans, La.

(Continued on page 491)

let us make a

Clipper *joint . . .*

for you

Are you looking for a better, faster way to fasten belts, aprons, tapes or ribbons? Would you like to slash maintenance time by putting an easy-to-fasten joint in endless belts? The fastest way to join these ends is with Clipper Hooks and Lacers.

Long used for lacing power transmission belting, Clipper fasteners are now proving their cost-cutting value in materials handling equipment, automatic pin setters, laundry equipment, food harvesting and processing equipment and in many other applications.

They produce a smooth, flexible joint in a hurry.

Let us demonstrate the advantages of a Clipper joint on the product of your choice. Send us a small sample (or the complete belt, apron, tape, or what have you) and we'll make you a Clipper joint FREE, without obligation.

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How to Do Away With Lock Nuts and Lock Wiring

use **HELI-COIL*** **Screw-Lock Inserts**

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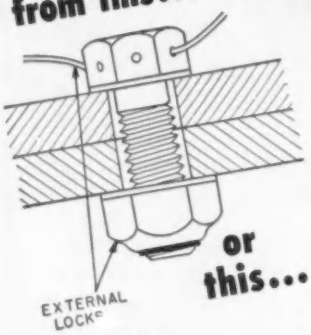
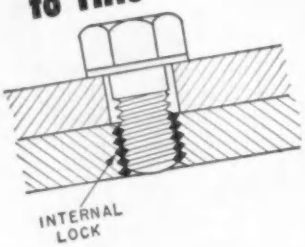


or this...

to THIS



Screw-Lock Inserts meet AN-N-5b and MIL-N-25027 military specifications for lock nuts.

For years designs requiring lock nuts or lock wiring have plagued designers with problems of space, weight and costs. Each lock nut, even a small one, takes space, has weight and costs money. Every bolt locked with wire requires a through hole in the head, positioning and wiring. The simplicity of many a superior design has been lost due to these cumbersome methods of fastening.

Now for the first time good designers can do away with these "design plaguers." They can accomplish the same end results plus a saving of weight, space and money by a new revolutionary concept in fasteners—*Heli-Coil* Mid-Grip Screw-Lock Inserts. This new fastener is a stainless steel wire insert with locking threads. It can be installed easily and puts the locking effect *inside* the tapped hole—protects the tapped threads for life—and locks the mating screw or the bolt with the same torque as a lock nut. This Screw-Lock Insert not only provides a stainless steel protecting thread, locks the screw or bolt, but most important of all—eliminates the space and weight of a lock nut—the wiring necessary in lock wiring.

Heli-Coil Mid-Grip Screw-Lock Inserts can readily be distinguished from regular non-locking *Heli-Coil* Inserts by their distinctive red color.

*Reg. U. S. Pat. Off.

HELI-COIL SCREW-LOCK INSERTS

Products of Heli-Coil Corporation, Danbury, Conn.

HELI-COIL CORPORATION
165 SHELTER ROCK LANE, DANBURY, CONN.

- ☐ NEW—Design manual available on regular *Heli-Coil* Screw Thread Inserts.
- ☐ RUSH complete design data on *Heli-Coil* Mid-Grip Screw-Lock Inserts.
- ☐ WIRE your nearest representative to phone me at_____
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☐ Heli-Coil Corporation has an outstanding staff of Thread Fastening Engineers. If your company would be interested in a "Thread Problem Symposium" CHECK HERE.

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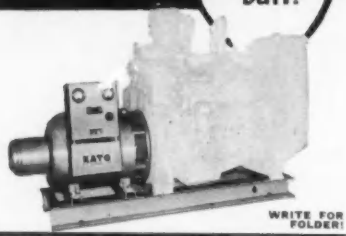

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In the wide range of Kato's line, you'll find a size with all the electrical characteristics to meet your specific needs . . . Standard frequencies 25- 50- 60-cycles. Special frequencies available from 15 to 800 cycles.

- **A.C. GENERATORS** 350 Watts to 500 KVA in one or two bearings in speeds of 720 to 3600 RPM.
- **A.C. GENERATORS** 15 to 800 cycles, single and 3 phase.
- **D.C. MOTORS** up to 10 H.P.
- **D.C. MOTORS** with A.C. take-off.
- **MOTOR GENERATOR SETS,** D.C. to A.C., A.C. to D.C., 25 cycles to 60 cycles, 60 cycles to 400 cycles.
- **D.C. GENERATORS** up to 20 K.W.
- **A.C. MOTORS** single phase, 1, 1½, 3 H.P. Available in all standard voltages . . . . 110/220, 220/440, etc.
- **ROTARY CONVERTERS** for changing D.C. to A.C.
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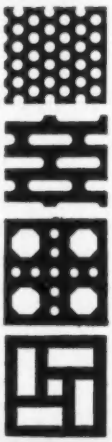


Several considerations must usually be observed. The design should be attractive in appearance and the percentage of open area should be adequate while, at the same time, affording suitable concealment of what lies behind or underneath. Naturally, also, the right metal should be used in the right thickness.

Whenever Perforated Metal is required, and it has thousands of applications today, you'll do well to contact Diamond. Forty years of widely diversified experience and hundreds of modern tool arrangements enable us to give unsurpassed service and delivery. Catalog 39 (32 large pages) gives complete illustrated information. No charge or obligation.

DIAMOND MANUFACTURING CO.
Box 40 WYOMING (Wilkes-Barre Area) PENNA.

National Gypsum last year purchased a tract of land from Bell Asbestos Mines Ltd., a subsidiary of Turner-Newall, London. The company since has acquired additional land and now owns a 500 acre tract. The company has two other Canadian operations; one at Halifax is considered to be one of the largest gypsum mining developments in North America. The other is a paint products plant at Montreal.

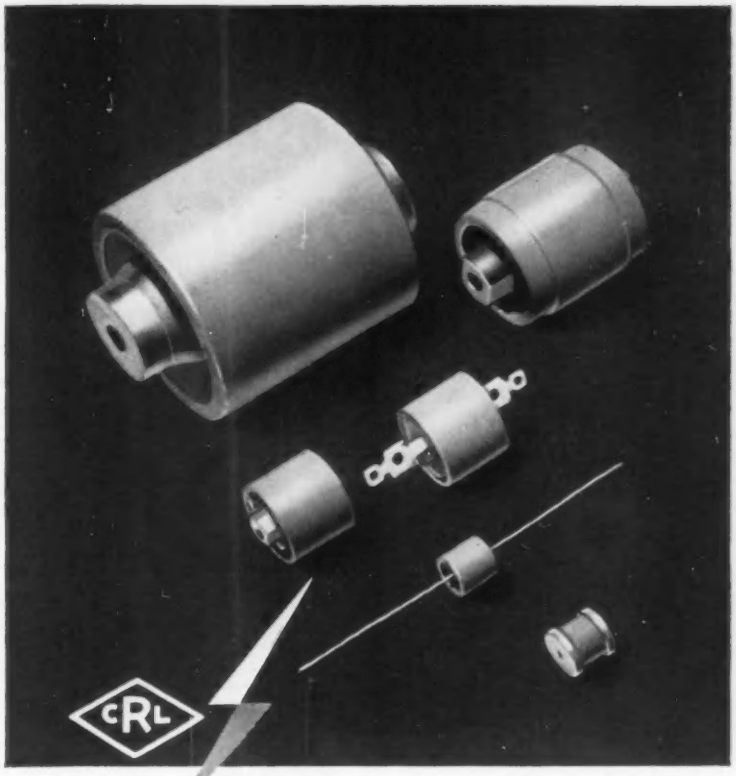
The new mine and plant will be operated under the name of National Asbestos Mines Ltd., a wholly owned subsidiary of National Gypsum Co. This acquisition continues National Gypsum policy of obtaining reserves of its basic raw materials. The new deposit is expected to reduce company costs and improve its market position. Robert S. Coleman, Manager of the new operation, said that the new plant will produce fibre primarily for National Gypsum Co. and will sell some other grades as they are available. The project is expected to be completed in 1958. Service buildings and roads will be constructed this year. Development work on the mine will be started either late this year or early next year.

Production Begun At Peerless Electric Plant

Production has started at The Peerless Electric Company, Warren, Ohio, new 350,000-dollar Fan and Blower Division Plant. President Ralph Kroehle stated that the new building, completed December 1, is part of a half-million dollar expansion program—largest in Peerless 63-year history. Kroehle cited a larger line and speedier customer deliveries as goals set up by the increased manufacturing facilities.

Walter A. Curtis, Manager of the Fan and Blower Division, predicted that Peerless will soon be producing about 400 different models of fans and blowers. "The new plant will enable us to eventually double production capacity," Curtis stated, adding the building gives his division 50 per cent more manufacturing space and more modern, mechanized facilities. All fan and blower production equipment has been moved from the former three-story factory into the new building; the original plant still houses Peerless'

(Continued on page 493)



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J.I.C.-NEMA Type 12
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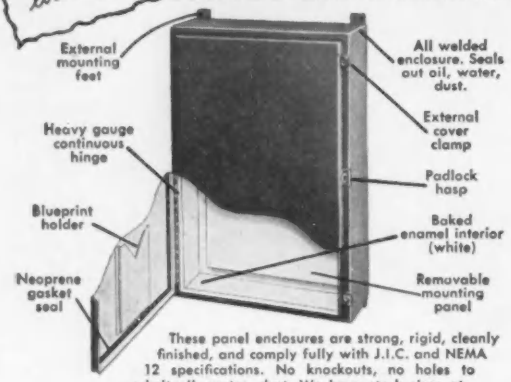

These panel enclosures are strong, rigid, cleanly finished, and comply fully with J.I.C. and NEMA 12 specifications. No knockouts, no holes to admit oil, water, dust. We have stock sizes at low cost for fast delivery. Or, we can make any size you want. We also make J.I.C. Wiring Boxes, Troughs, Push Button Stations and Rain-proof Power Outlets. Can we help you?

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20" x 16" x 6"	30" x 24" x 6"	42" x 30" x 8"
20" x 20" x 6"	30" x 24" x 8"	42" x 36" x 8"
24" x 20" x 6"	36" x 24" x 8"	48" x 36" x 8"

Ask your electrical jobber or write us direct.

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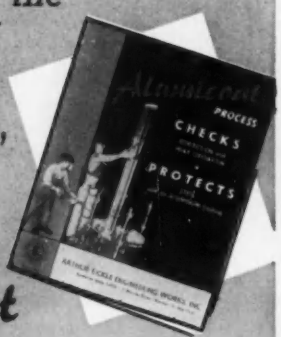
Have You Seen the Advantages of this **NEW "STEEL-SAVING" PROCESS!**

Send today for information describing the



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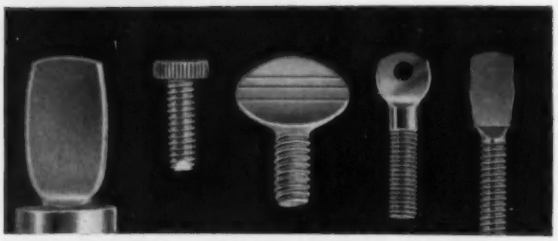
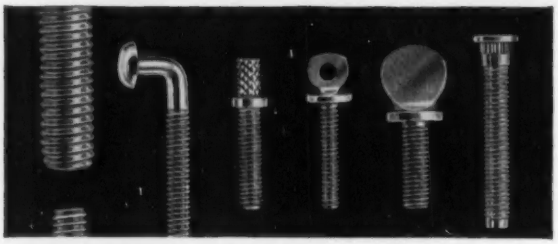
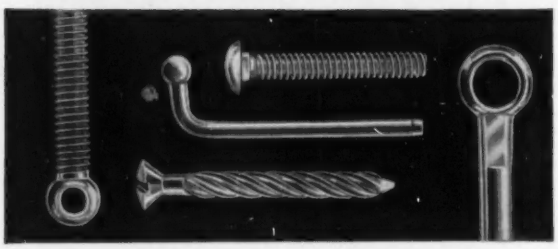


YOU CAN'T BEAT COLD FORMING



FOR PARTS LIKE THESE—AND



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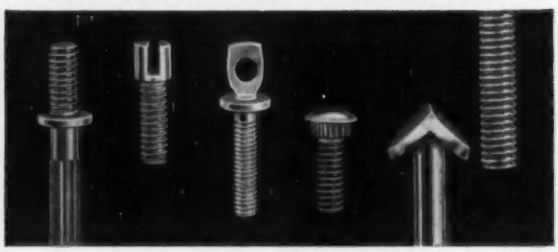
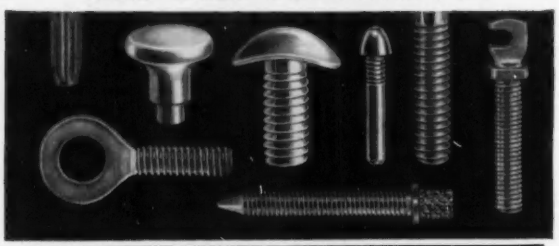


FOR COLD FORMING . . .



MACHINE SCREWS AND SPECIAL FASTENERS ARE OUR BUSINESS
. . . INCLUDING SQUARE AND HEXAGON MACHINE SCREW NUTS

WRITE FOR OUR CATALOG

THE PROGRESSIVE MANUFACTURING COMPANY
DIVISION OF THE TORRINGTON COMPANY
48 Norwood St., Torrington, Conn.

Electric Motor and Electronics Divisions. Officials said the vacated space was already slated for use by the other two Peerless divisions.

Peerless' present line of fans consists of exhaust and ventilating fans in sizes up to 48 in. for home, commercial and industrial applications, complete ventilating and air duct units, and shutters and other fan accessories. One of the first new products to go into production in the new plant is a new propeller-type roof ventilator, combining fan and weatherproof housing in a single unit. Another new product, a centrifugal power roof ventilator now in the development stage, will soon be produced in the new plant.

The 1955-56 expansion program at Peerless Electric is a continuation of an increase in production capacity that began in 1946 when a 200,000 dollar addition was built on to the original factory. In 1947 the firm added new shipping facilities and, two years later, enlarged factory offices. The first Peerless Electric plant was built in 1905, twelve years after the Elmer W. Gillmer organized the firm to produce floor and ceiling fans.

RPI Technical Writing Institute Reconvenes

Twelve technical writing authorities from national business and industry will be among the lecturers in the fourth annual Technical Writing Institute at Rensselaer Polytechnic Institute, Troy, N. Y., June 11-15. The seminar of lectures and workshop testing is designed to guide technical writing supervisors and apprentices. Nearly 200 company representatives have attended previous annual sessions.

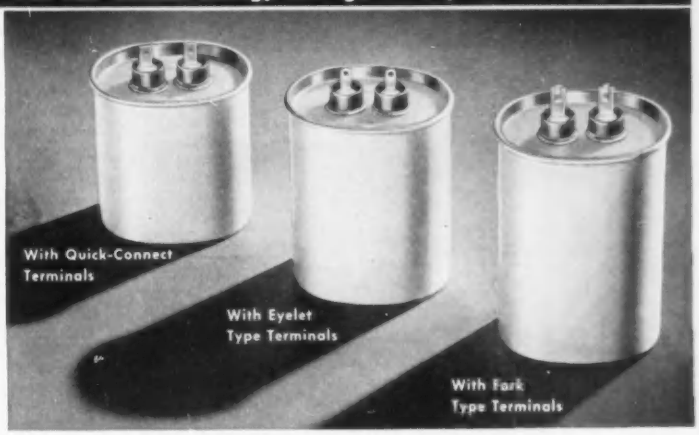
Sessions on manuals, handbooks, reports, trade promotion pieces, training programs, and graphic and illustrated materials are included in the lecture course and in practice writing counseling. New fields of inquiry this June will be writing for medical and pharmaceutical houses and for producers of industrial films. The Technical Writers Institute is organized under the R. P. I. Cooperative and Extension Group.

The special lecturers of the fourth Institute will include: Oliver H. Bu-

(Continued on page 495)

potter AC DRAWN OVAL Capacitors

For Air Conditioning, Refrigeration, Fan Motors, etc.



236, 330 or 440 volts, 60 cycles, A.C.

...save space, weight and cost!

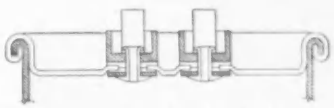
LEAK PROOF CONSTRUCTION:

Cases are seamless, and tops (see drawing) are joined to cases via a double-rolled seam which provides not only a perfect and permanent seal but also incorporates exceptional mechanical strength. No solder is needed or used.

SPECIAL IMPREGNANT:

Cases are filled with Chlorinated Diphenol Resin — an impregnant which is non-flammable and has high dielectric qualities. It has exceptional stability and long life, even at high operating temperatures.

CHOICE OF TERMINALS:

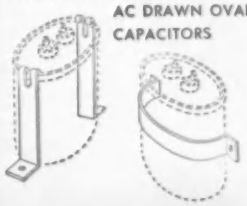


Three types of terminals, (see illustration) to fit your particular needs—speed connecting time whether you prefer mechanically joined or soldered leads.

WIDE RANGE OF SIZES:

Available for 236, 330 and 440 volts A. C., 60 cycles. Conventional or barrier type terminal mounting. Two types of mounting brackets.

MOUNTING BRACKETS FOR THE AC DRAWN OVAL CAPACITORS



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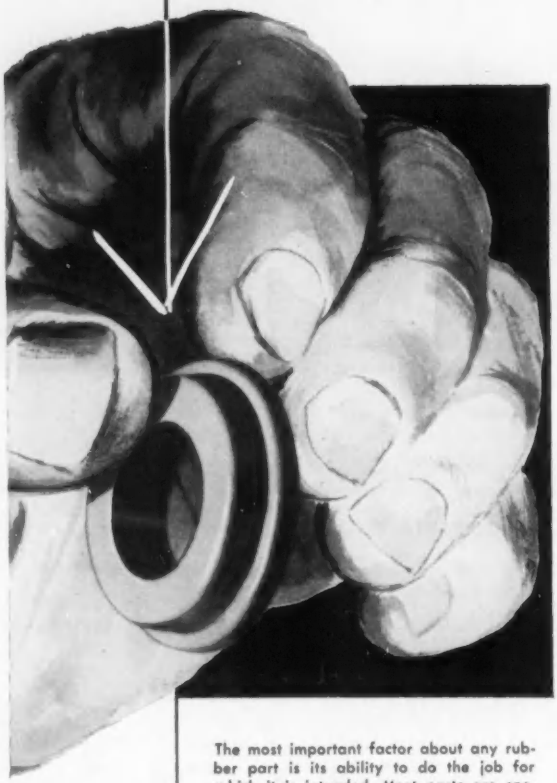

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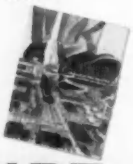
The most important factor about any rubber part is its ability to do the job for which it is intended. Most parts are specifically engineered for the application . . . and consideration is given to elasticity, temperatures to be encountered as well as resistance to petroleum derivatives, chemicals and abrasion.

STALWART ENGINEERS have the experience and facilities to compound special rubber stocks to meet even the most unusual requirements . . . and from more than 500 different compounds already at their disposal, they can mold, extrude, die-cut, lathe-cut or mandrel-build shapes to meet any specifications.

SPECIFY STALWART RUBBER PARTS FOR THAT ONE ESSENTIAL QUALITY . . . THE ABILITY TO DO A JOB . . . BEST!



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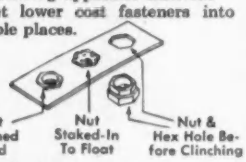
use these
GRIPCO CLINCH NUTS
with the exclusive
hex on hex
feature

for "fixed" fastenings for "hard-to-reach" or blind assemblies. They wear longer, hold tighter, give greater customer satisfaction.

See how leading appliance manufacturers get lower cost fasteners into inaccessible places.



Gripco Clinch Nuts can be either clinched solid for a rigid application or staked in with a six point staking punch to give a floating effect. This floating effect takes care of misalignment and makes the application of the bolt easier. Gripco clinch nuts can be clinched or staked with stationary or portable hydraulic or air equipment. Details on request. Write for samples and data sheet.

Typical Applications

Automatic Washer for leg leveling and crating on all appliances

Tractor Seats

Power Lawn Mowers

Automobile Frames

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solenoid engineering implements product ideas!

New or improved product design takes *all your knowhow.* Dormeyer *Solenoid Engineers* can contribute to your efforts with electro-mechanical devices that carry out your ideas *and even stimulate more.* Dormeyer Solenoids have streamlined appearance, simplified operation, allowed "package" maintenance, and increased service life of many products. Let's talk about yours:

Send product sketch for our recommendations . . . b/p or specs for estimate . . . no obligation.

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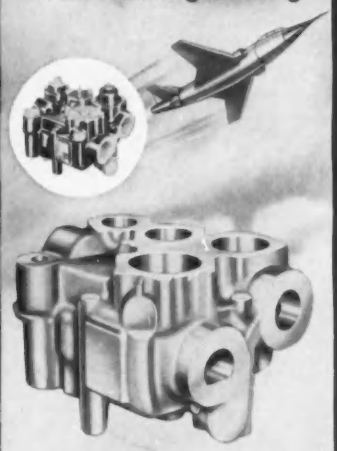
depends on
HAMPDEN BRASS
for
Main Housing Casting



The Engineers and Facilities of HAMPDEN BRASS were called upon by Chandler-Evans to help develop and cast this main housing.

The sand casting process was chosen because the intricate cores could be cast at lower cost while still maintaining high quality standards. Hampden Brass is proud to produce the main housing casting for Chandler-Evans's RC-9 Afterburner Control used on turbojet engines.

Your casting problems may be solved just as effectively through the use of Hampden Brass premium quality castings . . . by the sand, permanent mold or die casting methods. Our more than 50 years' know-how is your assurance of the best casting techniques to help reduce costs and improve performance.

Avail yourself of our engineering counsel . . . or write for a casting quotation today!

Send for brochure, "Behind the Scenes" . . . complete digest of Hampden Brass's experience, equipment and facilities.

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Established 1903
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Producers of Sand, Permanent Mold, Die & Fiberglas Castings

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Colt's Manufacturing Joins Penn-Texas

The Plastics Division of the Colt's Manufacturing Company, Hartford, Conn., has become a wholly owned subsidiary of the Penn-Texas Corporation and is now known as the Manufactured Products Corporation. Engineering, creative design and customer service departments are being expanded. The physical plant is undergoing reorganization for maximum productive efficiency; advanced manufacturing, materials handling and quality control methods are being incorporated.

Manufactured Products Corporation supplies a wide variety of standard or custom plastic products from jars, closures and other packaging items for the cosmetic and pharmaceutical industries, to plastic parts for industrial applications. Complete services include hot stamping and screen process methods of reproducing trademark, copy, design and decoration on packages and parts.

New AiResearch Facility Tests Components, Systems

Garrett Corporation's AiResearch Manufacturing Division has officially opened a 5 million dollar production test facility at Phoenix, Ariz.,–a mammoth laboratory facility for aircraft component parts. The giant test plant

(Continued on page 497)

CHROMALOX
Electric
TUBULAR HEATERS
provide controlled and dependable conduction, convection or radiant heat

These versatile Chromalox Tubular Heaters provide the kind of heat you need, exactly fitted to your specific heating application.

Available in straight lengths or formed to any desired shape. Used for heating dies, molds, platens; as immersion heaters in liquids, soft metal and molten salts; or in ovens, air ducts and other air heating applications.

Let the Chromalox Sales Engineering staff solve your heating problems . . . electrically

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—for full information on the complete line of Chromalox Electric Heaters and controls.

For ideas on additional applications of electric heat, request Booklet F1550—"101 Ways to Apply Electric Heat."

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overcome
power-spring hurdles

with **SANDSTEEL**
crosscurved mainsprings

Obstacles to a quality product, from the product engineer's standpoint, can often be overcome with the kind of reserve power *built into* Sandsteel mainsprings with the famous *Crosscurving* process. Only highest-quality Swedish steel can be used for this concave-convex construction that enables the use of longer, thinner springs... while assuring the reserve power needed and a longer, more even delivery of energy.

If you are designing a product requiring a flat-type mainspring, find out how Sandsteel Crosscurving can help you.

Write for FREE LITERATURE (Springs for Your Product) and CASE FILE, Dept. 41.

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Sandvik Steel, Inc., Fair Lawn, N.J.

coming your way!
L-R BLOWER WHEELS
A new source for precision wheels by Ripley — pioneers in the small blower field since 1936. Rugged, lightweight, and above all, easily adaptable to your air-moving needs.
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Superior RIPLEY ESTABLISHED 1936 ... through Research

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Livermont TORQUE LIMITER for POWER SCREWDRIVERS

ONE man does the work of *SEVEN* with this job-tested **TORQUE CONTROL CLUTCH**
(Frictionless new ball bearing principle. Eliminates slow hand torquing)

5 to 85 inch pounds capacity
PRICE: $75.00

Assures absolute torque control and accuracy. Can be used on any available power source, including automatic multiple-spindle drills. Even where torque control is NOT required this tool, with its free wheeling clutch release, quickly pays for itself by savings on bits and sockets.

30 DAY FREE TRIAL! Write for brochure and details. Dept. PE-556

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provides one of the largest privately-operated sources of compressed air in the world. It makes possible testing, research, and development–at a record rate–of hundreds of AiResearch components and accessory systems. Hundreds of miles of piping directs air at different pressures and temperatures to all parts of the laboratory for mass production testing purposes. Connected with the vacuum system, altitudes above 75,000 ft can be created.

Products tested at the Phoenix facility are gas turbine engines, air turbines, hot and cold air valves, refrigeration turbines, heat transfer equipment, and complete systems employing all of these components.

The big new building–whose screeching exhaust noise is bounced into the air off surrounding baffle boards–contains a number of concrete-enclosed test cells for sea level testing of gas turbine engines. Each has its own bank of calibrated instruments which can record as many as 35 variables simultaneously. These include pressure, speed, torque–all of which are analyzed as the engine runs at speeds of close to 45,000 rpm. Eighteen such cells, with foot-thick concrete-reinforced walls, are used for testing of air turbine starters, air turbine motors, and air turbine refrigeration units operating off a source of 300 psi at temperatures up to 900 deg F. Other cells handle gas turbine motors.

Four cells are instrumented to test gas turbine controls, accessory cases and heat transfer equipment with an air flow of 50 lb per mintue at 300 psig of ambient temperatures. Three cells test fuel nozzle patterns, flow quantities and related characteristics. There are 14 valve test sections. Compressed air from 250 to 1,000 psi, temperatures up to 1000 deg F, and flow rates from 15-250 lb per minute are provided. All can be set up for ambient discharge or the vacuum line for discharge at 75,000 ft.

In the altitude-tank division are six cabin altitude tanks–and one granddaddy heat and cold chamber. The cabin tanks are divided in the middle to create cabin conditions on one side and ambient air conditions in the other. The altitude created is from 1,000 ft below sea level to 75,000 ft above with 200 lb air flow. The chambers are used to test cabin pressure

(Continued on page 499)

New Ideas for Design Engineers with POLYPENCO® Non-Metallics

A wide range of materials and services offering significant advantages in multi-product planning

Polypenco non-metallics are proving of great advantage to designers who value the importance of design flexibility. These non-metallics are available in a wide range of materials and forms:

Polypenco stock shapes in Nylon, Teflon and Q-200.5 provide low cost machining into components of superior quality and performance . . . and new Polypenco developments will give you new engineering advantages at lower cost.*

Whatever your design calls for—chances are you can develop the part advantageously and inexpensively from one of these materials:

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Polypenco Nylon: rod, strip, tubular bar, slab, tubing

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A new ferromagnetic plastic material—available in flexible forms.

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WHIRLCLAD† COATING PROCESS—Licensed by Polymer Processes, Inc. For applying nylon, polyethylene and other coating materials to metals, ceramics, wood and other base materials.

These materials and services will be exhibited at the Design Engineering Show, Booth 922. Or write for helpful information.

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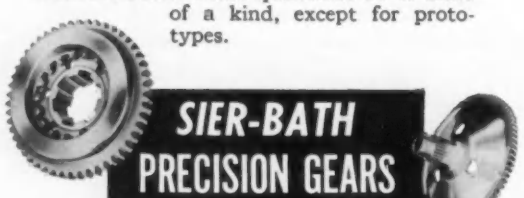

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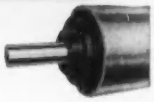
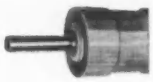


Wood rolls for wet or dry service



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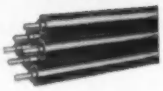
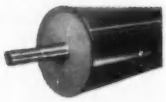


Chromium plated steam and cooling rolls



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The manufacturing building contains all production equipment as well as parts and raw-material storage, and adjoins the laboratory. Curtain-type interior wall construction and special mounts for production machinery provide the flexibility to adapt this area to any future pattern of production requirements. A third building houses engineering and administrative offices and such service facilities as archives, library and cafeteria. All divisions and departments have been tied together by an internal dial phone system and by pneumatic tubes for written and printed informatoin.

Special care has been taken to fit the new plant to its environment of

Selas Moves To Larger Facility

Selas Corporation of America has moved from its Philadelphia site to a new million-dollar plant in the suburbs just north of the city at Dresher. The 11-acre site has been developed to provide fully coordinated facilities for all of the company's activities. The move was made necessary by rapidly expanding markets for the heat and fluid processing equipment which Selas develops, designs and builds for all industries.

All research and development is now concentrated in one centrally located building specifically designed for intensive study of heat and fluid processing. The only exception is the ceramics laboratory, which adjoins the ceramics production area in the manufacturing building, for convenience to the necessary kilns.
regulators and superchargers. Compressed air supplies pressures up to 300 psi; temperatures from −65 to 500 F., and air flows up to 350 lbs. Diving or climbing to flight conditions can be duplicated from sea level to 75,000 ft—or vice versa—in one minute. A test stand for ram air turbines, for emergency hydraulic power to aircraft, supplies oil at 3,000 psi at a flow rate of 15 gpm.

In other rooms, instruments evaluate speed and torque transmission of gas turbine engines, air turbine starters, and other equipment; vibrators shake electrical apparatus at high frequencies to determine shock resistance in actual flight.

(Continued on page 501)

spot-welded seams are water, moisture and dust tight when sealed with . . .

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Here are the cold facts about Presstite cold-applied Mastic Sealer No. 525:

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homes and farms. The site drops away from the road, and the buildings are recessed into the landscape. The visitor's entranceway, the only portion of the plant visible from the road, is a curving driveway into a court designed and landscaped to resemble a school or one of the several nearby country clubs. The rest of the buildings are screened by extensive planting of mature trees and shrubs, remaining from the former use of this land as a nursery. The buildings are arranged in a U around an extensive employees parking lot and delivery area, with the open end facing a spur of the Pennsylvania Railroad and the eastern extension of the Pennsylvania Turnpike, which expedites shipping and deliveries while screening them from neighboring residential areas.

The move to the suburbs was made necessary when the rapidly expanding markets for Selas processing equipment made the old plant of 84,000 sq ft of floor space, on 2½ acres, inadequate. The built-up adjoining area at that site made impossible any further expansion. Extensive negotiations with the county planning commission, the town council, and with individual home owners in the immediate neighborhood made it possible for Selas to move into an agricultural and residential neighborhood without opposition. This planning was extended to consideration of the location of employe's homes, and to hiring—with the new plant site in mind—for more than a year before the move, so that only 10 of the company's 500 employees left because of the move.

Production Starts on J & L Galvanizing Line

Production has started on a 6¼ million dollar continuous hot-dip galvanizing line according to Jones & Laughlin Steel Corporation. C. L. Austin, J & L President, said that the new galvanizing line, which utilizes the Armco-Sendzimir process, has a rated capacity of 7000 to 8000 tons of galvanized sheets a month. "This gives users a new source of supply for galvanized sheets, produced by equipment that is the most modern available, and incorporating the latest technical advancements," said Mr. Austin.

The new facility is another step in

(Continued on page 503)

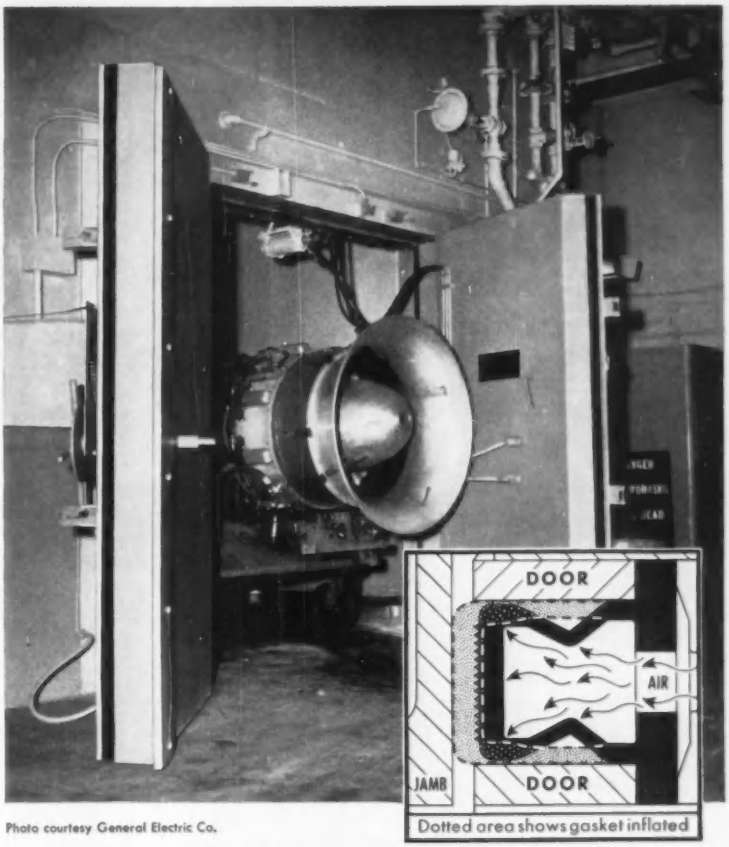

Photo courtesy General Electric Co.

Pneumatic Rubber *Door Seal* Muffles Test Cell Noises

To more effectively suppress noise, General Electric jet engine test cells are equipped with a unique pneumatic rubber door seal. Mounted on door perimeter, this seal is designed to expand proportionally and insure a perfect seal over its entire sealing surface *including the corners*. Not only does this gasket dampen the noise but it permits more accurate testing through quieter working conditions.

Continental engineers developed this pneumatic gasket for this and similar applications. Compounded of special flex-resistant rubber, this versatile gasket can be operated with intermittent flexing cycle *or* as a continuous seal—can be adapted to various other types of doors—for *either* pressure or vacuum rooms.

The design of this gasket typifies the engineering skill offered by Continental. When you need "engineered rubber parts"—molded or extruded—enlist the service of specialists—consult Continental.

Engineering Catalog.

In addition to custom-made parts, Continental offers an extensive line of standard grommets, bushings, bumpers, rings and extruded shapes. Hundreds of these are shown in the No. 100 Engineering Catalog. Send for a copy or refer to it in Sweet's Catalog for Product Designers.

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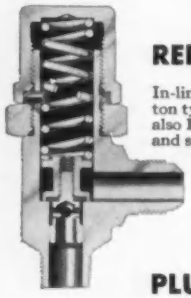

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In-line and guided piston type Relief Valves, also Pilot Operated, with quick unloading and silent operation. Metal or rubber seal. ⅛" to ¾" pipe or tube port connections. Various metals.

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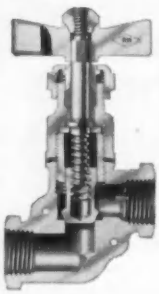
Precision-made Plug Valves for wide general use in brass, aluminum alloy, or stainless steel, ¼" to 1", +32° to 160°F. With Teflon plug, −65° to 250°F, without lubrication. Aluminum alloy or stainless steel.



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Super duty shut-off valves, angle and offset, for up to 3000 service, ⅛" to 1". Also high pressure Needle Valves for 10,000 psi. working pressure—proofed at 25,000 psi. One piece, stainless steel, ⅛" to ½", Teflon packing.

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● *Since 1928, SEAMLEX Products are QUALITY Products.* ●

the latest phase of J & L's improvement and expansion program. Last October, J & L announced it would spend 250 million dollars in the 1955-1958 period. The new Continuous Galvanizing Department, an addition to J & L's Pittsburgh Works, is located near the site of J & L's old Soho open hearth furnaces, which have been dismantled. The line is housed in an L-shaped building, 750 ft long and 100 to 175 ft wide. In addition to the line, the building contains a coil storage area, the warehouse and shipping department, and office, maintenance and control areas. The mill is producing galvanized steel both in sheets and in coils.

John E. Timberlake, J & L Vice President–Sales, has this to say about the new galvanizing line: "We decided on the Armco-Sendzimir Process because our investigation showed that it produces galvanized sheets having excellent adherence, good forming properties, and an attractive lustrous appearance." Mr. Timberlake further points out that the new continuous galvanizing line will diversify J & L's line of flat-rolled products.

Howard A. Knox, Manager of J & L's Sheet Mill Products Division, says: "The continuous hot-dipped product is considered to be far superior in quality to the old style hot-dipped-pot-galvanized sheet, permitting new applications not possible with the conventional type."

With the advent of the continuous galvanizing process and its high quality product, the demand for galvanized sheets for a wide range of uses has increased yearly. One of the most rapidly expanding markets for continuous galvanized sheets is for centralized heating plants and domestic heating and air conditioning.

The process being used by J & L was developed by Tadeusz Sendzimir and patents covering the process were granted him in 1938 and 1940, now controlled by Armco Steel Corporation. In the Sendzimir coating process, the surface of the base metal is oxidized to remove rolling lubricants and other combustible material by passing the strip continuously through a furnace. The strip then passes into another furnace where the metal is annealed. The cooling furnace is connected directly to the annealing furnace and extends to the zinc bath

(Continued on page 505)

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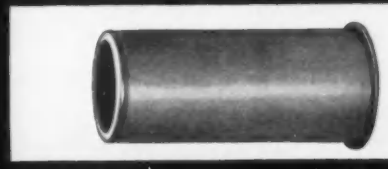

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Could a way be found to retool the original housing at a lower cost? Presteel engineers, backed by 73 years of stamping know-how, went to work.

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Result: Manufacturing costs, less materials, cut 29% . . . labor requirements reduced substantially, offsetting mounting raw material costs. What's more, production time was slashed 83.3%, with 18 days' previous output produced in just three days! And Bendix could afford to use the original housing design again!

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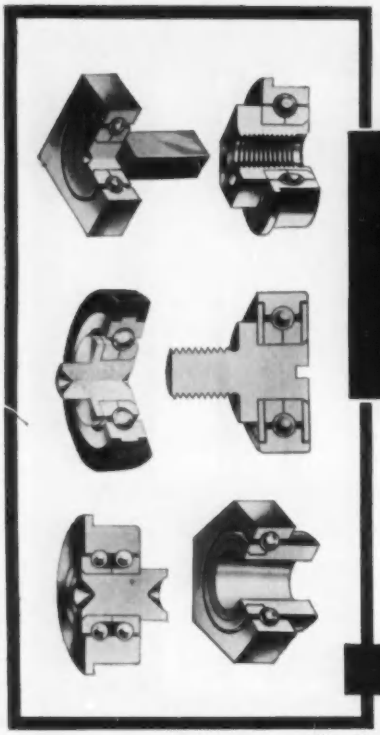

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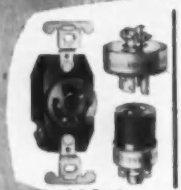

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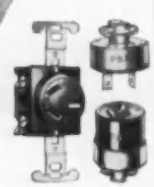

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with its end sealed by molten zinc. This furnace controls the rate of cooling of the strip in a non-oxidizing atmosphere. Dissociated anhydrous ammonia serves as a reducing atmosphere in the annealing furnace and as a non-oxidizing atmosphere in the cooling furnace. The annealing-cooling furnace is air-tight because the entrance of any oxygen would result in reoxidizing of the strip and spoil its wetting characteristics. The strip is immersed in a flux-free molten zinc bath, where wetting and bonding occur instantaneously. A rapid reaction between the zinc and the base metal takes place.

The J & L line is 610 ft long overall. The oxidizing furnace is 20 ft long, the reducing furnace 104 ft long, and the controlled cooling furnace 224 ft long. The line will operate for 13 weeks continuously before it is shut down for drossing (removing the wastes from the bottom of the pot) and maintenance. The galvanizing department's raw material, in the form of cold-rolled steel bands, is delivered from the adjoining continuous sheet mill.

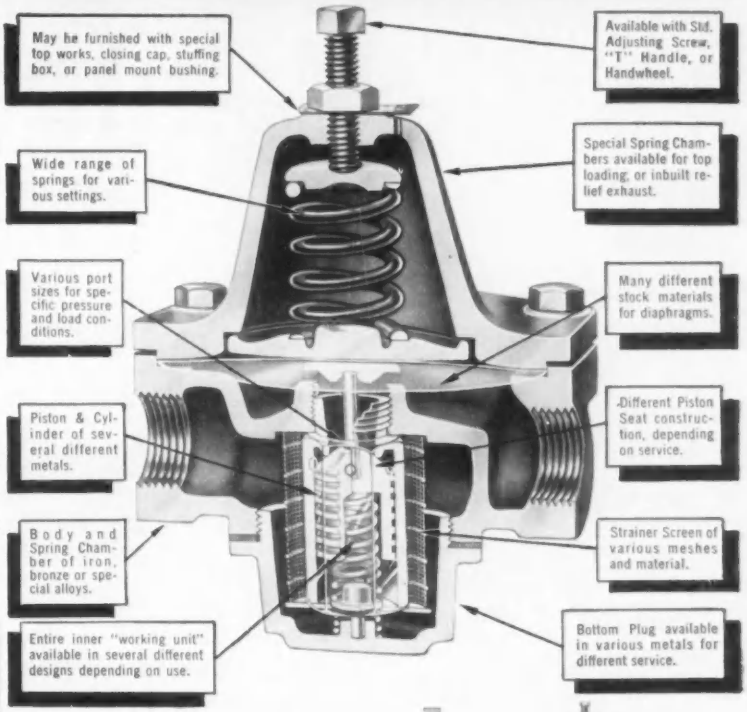
Chromalloy Corporation Holds Open House

The move into a new plant at White Plains, N. Y., was celebrated by Chromalloy Corporation with an open house for guests representing industrial concerns, government agencies and members of the trade press. The Chromallizing process was demonstrated showing how heat, wear and corrosion resistance of ferrous and certain non-ferrous metals can be increased by high temperature diffusion of chromium into the metal surface. An 8-page booklet, "This is Chromalloy" was prepared, Chromallized products and parts were on display, and application photos and photomicrographs of structures exhibited. A microscope was set up for structure examination and oxidation and nitric acid tests were performed.

Plant equipment includes mixers, sifters and crushers for powder preparation, a large degreaser for part preparation, furnaces of various sizes and types with special retors for production processing, and the necessary

(Continued on page 507)

how *Cash-Acme* provides the *Correct Answer* to 1,017 reducing valve cost problems


May be furnished with special top works, closing cap, stuffing box, or panel mount bushing.
Available with Std. Adjusting Screw, "T" Handle, or Handwheel.
Wide range of springs for various settings.
Special Spring Chambers available for top loading, or inbuilt relief exhaust.
Various port sizes for specific pressure and load conditions.
Many different stock materials for diaphragms.
Piston & Cylinder of several different metals.
Different Piston Seat construction, depending on service.
Body and Spring Chamber of iron, bronze or special alloys.
Strainer Screen of various meshes and material.
Entire inner "working unit" available in several different designs depending on use.
Bottom Plug available in various metals for different service.

Here's How: With over 1,017 models and modifications of Cash-Acme's *standard* Type B Pressure Reducing Valve available and already in high production, the *right* regulator can usually be quickly selected from stock to do the job you require. This offers important cost savings as delays, special tooling and custom design and engineering are eliminated.

Do as other cost conscious engineers and purchasing men are doing and switch to CASH-ACME.

A fact-jammed eight-page bulletin, with honest and accurate capacity charts, is available free of charge. Write today.

Type "B"—Rugged Industrial Type Pressure Reducing Valve ... A truly *universal* piece of equipment. Standard models for:

- STEAM
- HOT WATER
- COLD WATER
- AIR
- LIGHT OIL
- NO. 6 OIL
- AMMONIA
- DIFFERENTIAL REGULATOR
- WITH INBUILT RELIEF
- AIR OR OIL TOP LOADING
- PANEL MOUNTING

FOR THE *Correct Answer*

CASH AUTOMATIC VALVES ACME

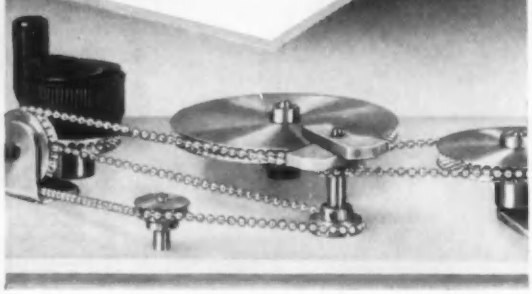
A. W. CASH VALVE MANUFACTURING CORP.
6662 East Wabash Avenue
Decatur, Illinois

FOR POSITIVE, LOW-COST

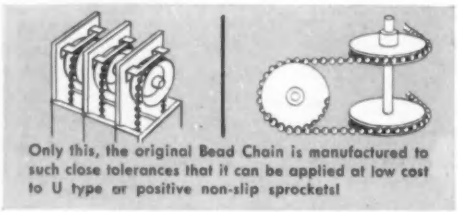
SPROCKET DRIVES...

it will pay you to use genuine

Bead Chain



Only the manufacturer of *genuine* Bead Chain offers you a new, more versatile belt drive that will accurately time and control the movement of all types of devices. Among such applications are radio and television tuners, recorders, air conditioners and timing devices. Costly gearing mechanisms can be eliminated and efficiently replaced by the specially designed sprockets that accurately fit the individual beads *without slippage and backlash.* Friction is at a minimum and tensile strength of the Bead Chain belt (from 15 to 200 lbs.) is very high in proportion to size and weight.



Only this, the original Bead Chain is manufactured to such close tolerances that it can be applied at low cost to U type or positive non-slip sprockets!

Write to us today for detailed information about sprockets and Bead Chain belts. It can save you a lot of time and money later.

THE BEAD CHAIN MANUFACTURING CO.
92 Mountain Grove St., Bridgeport, Conn.

Please send me information about Bead Chain sprocket drives.

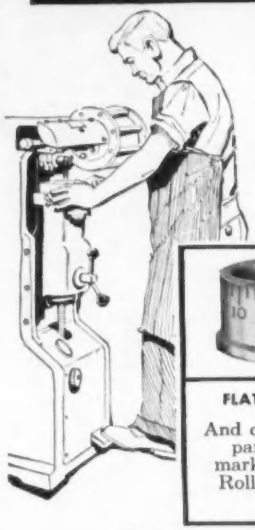
NAME.....

TITLE.....

ADDRESS.....

THE BEAD CHAIN MANUFACTURING CO., Bridgeport 5, Conn.
original and world's largest producers of Bead Chain

PRODUCTION MARKING



Speed your production with a GENERAL PURPOSE MARKING MACHINE. Several models available for quick, safe, light or heavy-duty marking of round, flat, or contoured parts, at rates up to 800 per hour!

ROUND PARTS

Held in Cradle Rolls, are marked with Flat-Roll Dies.

FLAT PARTS

And contoured parts are marked with Roller Dies.

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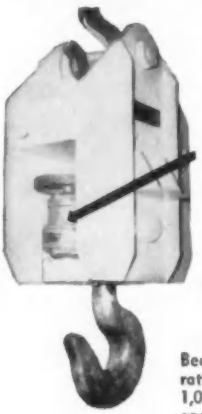
BOSTON • CHICAGO • PHILADELPHIA • CLIFTON, N. J.



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in the new Heppenstall Rotating Crane Hook

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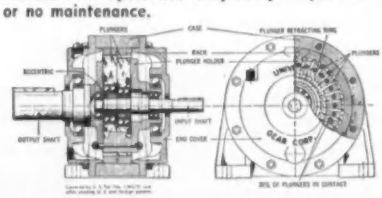
Because it gives higher torque and wider ratio range in minimum space; 20:1 to 1,000,000 ratios. Compact Design. Balanced Load Action. . . Two complete assemblies distribute power for unsurpassed smoothness. Low Cost, Trouble-Free Operation. Only two principal moving parts. Little or no maintenance.



For your requirements, write or call IV 2-1346 for complete information.

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handling equipment to service such units. There are also gas fired and electric experimental furnaces. A Globar furnace is used essentially for high temperature processing and oxidation testing.

Boeing Plans Revealed For Development Center

Boeing Airplane Co. has announced plans for a 21 million dollar developmental center near its main plant in Seattle adjacent to Boeing Field. The center will include four main buildings and other structures which will add 1,021,000 sq ft of covered area to company operations. Certain phases of guided missiles, physical research, structural testing and experimental activities are among the functions which will occupy the area.

Aviation observers believe that the first prototype plane to be built in the center may be a supersonic heavy bomber, eventually to replace the Boeing B-52 Stratofortress. Largest of the new buildings will have a total floor area of 754,000 sq ft. The buildings are expected to be completed and in operation by the fall of 1957. The project will be completely company financed.

A new manufacturing facility at Renton, Wash., of approximately 558,000 sq ft and costing 8.5 million, will be built adjacent to the present government-owned plant. Major portion of the new facility will be used for assembly of body sections of the Model 707 commercial jet transports, for which Boeing has received contracts from domestic and foreign airlines. This plant will also be company financed.

New Aviation Firm Formed

The formation of a new company, Clemco Aero Products, Inc., has been announced by Mr. John D. Taylor, a Buffalo, New York industrialist. This concern will be housed in a new 75,000 sq ft plant, at Compton, California. Clemco Aero Products, Inc. will be engaged in the machining of missile fins and structural sections of aircraft, the milling of aircraft wing

(Continued on page 509)

NEW! BENDIX-FRIEZ DESIGNER'S THERMISTOR KIT

12 Individually Packaged Rod-Type Elements, 25 to 1,000,000 ohms range

Here's a real time-saver for the busy designer from Bendix-Friez.* This new Rod-Type Thermistor Kit contains twelve standard elements for applications in sensing, controlling and indicating devices. Handy compartment case keeps thermistors separate and ready for quick use. Indexed boxes save time, assist in specifying and ordering.

These twelve thermistor elements range in resistance from 25 ohms to 1,000,000 ohms. Kit comes complete with specifications, covering dimensions, voltage-current characteristics and temperature resistance relationships. An up-to-date list of references are cataloged for your convenience according to thermistor applications. Mass quantities available for any or all of these 12 different thermistors.

*Reg. U. S. Pat. Off.

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Gentlemen:
Enclosed is my check for $.....(add .50 per kit for packing and shipping charges). Please send..... No. 100 Designer's Thermistor Kits. C.O.D.'s accepted.

Name.....

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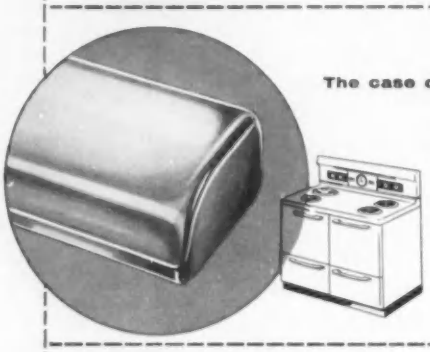
Actual case histories of unusual design problems solved by Pyramid Mouldings

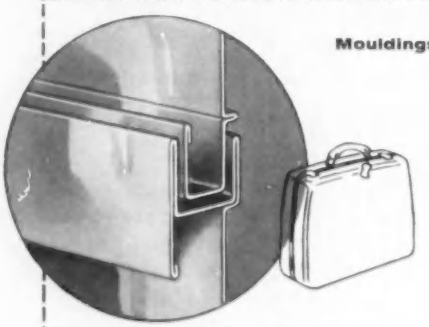
Pyramid Mouldings

Design Clinic



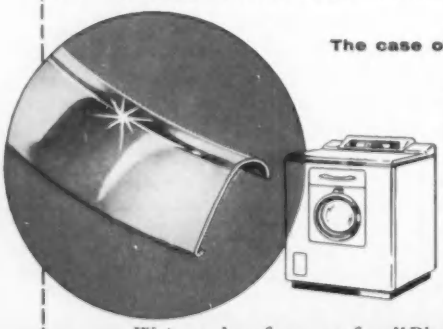
The case of the range lamp...

following the trend to longer lines has been ideally answered with rolled mouldings. Made to any desired length without change in tooling, ends are often formed as shown to eliminate costly end caps.



Mouldings made "case" history...

in one of America's leading luggage lines by adding the finishing touch to smart styling with these intricately formed bezels. Rolled to shape and bent to exact case contour, they covered raw edges, added structural strength, provided dustproof construction.



The case of the missing "drop-out"...

has meant money to the many manufacturers who have found that mouldings rolled in spirals and cut in circles eliminates waste unavoidable with stamped parts. Bezels, burner rings or *any* ring or bezel can be economically roll formed by Pyramid.

Write today for your free "Plan Book of Metal Mouldings"

Pyramid Mouldings Inc.

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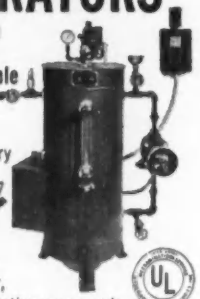

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Some say this should be our name. We do make heating elements in any shape insulated with *silicone rubber* or other materials.

but, we also make units with any degree of FLEXIBILITY —and when you need special attributes such as

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skins and the production of quick disconnect fittings for aircraft and missile pneumatic lines. Its machinery is classified as heavy industrial, with emphasis on two-dimensional and three-dimensional duplicating and profiling. Mr. Taylor will serve as president of the new organization. Mr. R. Glenn Gorman will be Vice President and General Manager. Mr. Gorman has been engaged in industrial and aviation engineering and manufacturing work for the last 15 years.

RCA To Open Ferrite Development Laboratory

Radio Corporation of America has announced plans for the establishment of an Advanced Development Laboratory in the New England Industrial Center at Needham, Mass. A modern one-story brick building, comprising 20,000 sq ft. has been leased from Cabot, Cabot and Forbes Co., developers of the Center. The Needham plant will be utilized for advanced developmental work on ferrites under the direction of Dr. Francis E. Vinal.

Operations at Needham will be an extension of RCA's work on ferrites which has been under way for some time. Product design utilizing ferrites will be continued at Camden, N. J., and Findlay, Ohio. The Needham laboratory will be the second plant to be established by RCA in the Boston area. Early in 1955, RCA opened an Aviation Systems Engineering Laboratory in Waltham for the development of specialized electronic fire-control systems for military aircraft.

Sylvania Projects New Plastics Plant

Plans for a new 110,000-sq-ft plastics plant, to be erected in Warren, Pa., have been announced by the Parts Division of Sylvania Electric Products Inc. Marion E. Pettegrew, general manager of Sylvania's Parts Division said that the new plant will be directly across from the Division's present Wire and Plastics plant. All plastics operations in this plant will be transferred to the new location. The present plastics operational space will be

(Continued on page 511)

Engineering FACT SHEET

CARBOLUBE

Self-Lubricating Bearings, Bushings, Seals, Contacts, Parts

WHEN LUBRICATION IS IMPRACTICAL OR IMPOSSIBLE SPECIFY CARBOLUBE

Typical examples: Valve Parts, Bearings, Friction Clutches, Seal Rings, Sliding Contacts, Piston Rings, Pistons

CARBOLUBE IS APPLICABLE WHERE:

1. Oil lubrication is inconvenient, expensive or impossible
2. Chemical corrosion attacks oil, grease
3. Bearings, seals or parts are inaccessible
4. Extreme temperatures reduce operating efficiency or make lubrication inefficient
5. Current is transferred between moving parts
6. Weight reduction is necessary
7. Bearings, seals or parts are submersed in liquids
8. Lack of fumes, cleanliness are necessities
9. Electrical parts are subject to pitting or fusing

CHARACTERISTICS OF BABBIT & COPPER CARBOLUBE

(Range between limits, according to grades)

Weight: 1¾ to 3 oz./cu. in.

% of Metal (by weight): 35%–70%

Tensile Strength: 3,900–5,500 lbs./sq. in.

Compressive Strength: 16,000 – 30,000 lbs./sq. in.

Coefficient of Friction: constant and low.

Coefficient of Expansion: approx. ½ that of iron or steel.

Bearing Load Pressure: 20-50 lbs./sq. in. on the projected area.

Speed: 1,500–7,000 FPM, depending on grade.

Operating Temperature:
Babbitt, to 350 F.*
Copper, to 750 F.*
Non-Metallic, to 750 F.*

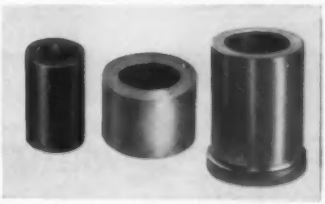
*In air or oxidizing atmospheres. Higher temperatures allowable in non-oxidizing atmospheres.

Machined Molded Parts

Corrosion-Resistant, Metal-Impregnated or Plain Carbon Bearings or Other Parts. . . . Need No Oil or Grease

Carbolube is carbon-graphite impregnated with babbitt, bronze, copper, cadmium, silver or non-metallics. The result is a completely homogeneous material whose self-lubricating and corrosion-resistant qualities are *inherent*, regardless of wear.

Formed by molding under carefully controlled conditions, Carbolube products are available in a great range of metals and carbons adaptable to your specific needs. Carbolube is also available in *non-metallic* impregnated parts. Write for complete engineering data indicating your specific application.



Plain Bearings: Thrust, Journal, Guide

BACKED BY YEARS OF RESEARCH AND DEVELOPMENT

Carbolube is a product of the Carbone Corporation, American manufacturing affiliate of one of the world's greatest manufacturers of mechanical carbon – Soc. Le Carbone-Lorraine.

Carbolube was first produced in 1950, embodying the most advanced ideas in the field.

Years of research have resulted in a complete series of grades of Carbolube for almost every specific application within the range of mechanical carbon parts. Our technical staff will gladly help to solve your specific design problem.

AVAILABLE IN A WIDE RANGE OF TYPES AND PRODUCTS

THE CARBONE CORPORATION BOONTON, NEW JERSEY

The badge of quality on your product

The users of your product respect the name Marsh on a pressure gauge or dial thermometer. Adopt Marsh Instruments and you will know why they have become "The Standard of Accuracy". There is a Marsh for every service.

Ask for this new catalog... It covers your instrument requirements.

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henceforth devoted to lamp-base manufacture by the Division. Plans for completion of the new plant are scheduled for December 15.

The additional floor space will allow the Division's plastics operations to expand its high-speed automatic molding of electronic and non-electronic parts. When the new buildings are completed, Sylvania's facilities in Warren will account for some 310,000 sq ft of manufacturing space. With the completion of the new building, the Division will have three plants in Warren, one in York, Pa., one in Nelsonville, Ohio, one in Cleveland, Ohio and its newly acquired formatic plant in Naugatuck, Conn.

International Firm Formed to Market French Electronic Products

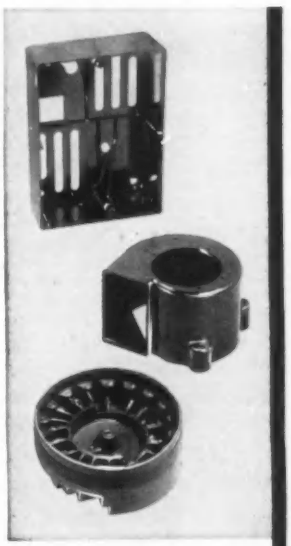
The Compagnie Generale de Telegraphie Sans Fil of Paris, France, one of the leading European electronic companies, and Airborne Instruments Laboratory, Inc., Mineola, New York, have announced the formation of an American company, called the Intercontinental Electronics Corporation, to manufacture and market electronic products developed in France.

Hector R. Skifter, President of Airborne Instruments Laboratory, Inc., and a member of the Board of Directors of the newly formed corporation states, "It may not be generally recognized, but, since the end of World War II, tremendous strides have been made in engineering in the European countries, particularly in France. In spite of the tremendous advances in technology made in America, we have found that CSF and its group, representing a major portion of the know-how of French electronics, can and will contribute substantially to our engineering efforts by offering to us an opportunity to join with them in a unified program of engineering. We anticipate that tremendously valuable progress lies ahead for the electronics field as a result of our combined efforts in this new company."

CSF has been established 46 years in the electronic industry, having developed and installed the first radio telegraph link to be set up in a tropi-

(Continued on page 513)

talk about **injunuity**



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in plastics too...

. . . you'll find it, *without reservation,* at Kurz-Kasch. We keep our wigs warm worrying about your plastic problems. The more complex the shape, the more intricate the mold . . . the more we enjoy *unzipping your woes.* We have the men, the equipment, *and many moons behind us!* We can efficiently handle your job completely from design to finish! Compression, transfer and plunger molding are second nature to us.

In one pow-wow, we can tell you if your part can best be molded in one of the standard thermo-setting plastics or if the newer Teflon or glass-filled polyesters would serve you better.

. . . and speaking of *injunuity* . . . here *they'd go bald* trying *to save your scalp.* Kurz-Kasch can be a "heap big help" —why not give us a call?

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STOW flexible shafting
ON THE JOB

pumping GAS on a tractor-trailer

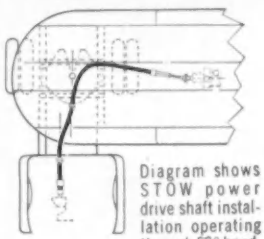


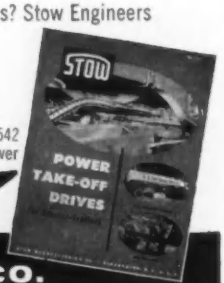
Diagram shows STOW power drive shaft installation operating through 90° bend.

STOW Flexible Shafts have effectively solved power take-off problems on both trucks and tractor-trailers. Large shafts, such as the 1¼" pictured above which transmits up to 10 H.P., have proven their ability on power take-off applications more efficiently and with more trouble-free service... **to operate pumps** for petroleum, milk and other liquids; **to operate conveyors** for grain, coal; **to operate compressors** on refrigeration trucks.

Why not put Stow to work on your power drive problems? Stow Engineers are always at your service.

For complete engineering data and illustrations on STOW Flexible Shafting—Write today for FREE Bulletin 525.

Write today for Bulletin 542 and complete data on Power Take-Off drives.



STOW MANUFACTURING CO.

426 STATE ST., BINGHAMTON, N. Y.

cal country and designers of the Carcinotron micro-wave tube. With its 10,000 employees, of which 2500 are trained engineers distributed over 18 French companies, CSF and its group is one of the chief European electronic concerns.

AIL has grown from a wartime team doing work for the Office of Scientific Research and Development to a company active in the electronic fields of radar and navigation, air-traffic control, medical diagnosis, nuclear technology, special systems and components, countermeasures, and automatic controls for the automotive industry.

Neoprene Coated Fabric Growing in Demand

The Vulcan Rubber Products "Duroflex" plant at Buene Vista, Va., has within two years grown from a six-man shop to a modern multi-million dollar organization. A lightweight neoprene-coated nylon fabric called "Coverlight" is said to be largely responsible.

Three years ago Vulcan merged with Reeves Brothers, Inc., a leading maker of fabrics for the apparel industry, which wanted to expand in the industrial fabrics field. Vulcan was set up to make a broad range of rubber coated products required by new applications in industries such as aviation, trucking and high speed offset printing. Since then, the plant in Buene Vista has been enlarged several times to meet the increased demand. Vulcan expects to soon have the broadest product range in the tarpaulin fabric industry.

A Vulcan "Coverlight" tarpaulin can be handled by one man, providing workable coverings for fleet operators with one-man trucks. As a result of such coverings as "Coverlight", truckers reportedly are turning to open-top trailers, cheaper to maintain and more flexible for loading. These tarps are said to be waterproof, acid and oil resistant, and will resist mildew and fungus. They have dimensional stability, can fit intricate patterns and forms unusual shapes. The product is described in a new brochure "The Ultimate in Industrial Coated Fabrics", obtainable from Vulcan Rubber Products Division, Reeves Brothers, Inc., 54 Worth St., New York 18, New York.

SEARCHLIGHT SECTION

(Classified Advertising)

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Individual Spaces with border rules for prominent display of advertisements.

The advertising rate is $16.85 per inch for all advertising appearing on other than a contract basis. Contract rates quoted on request.

An advertising inch is measured ⅞" vertically on one column, 3 columns—30 inches—to a page.

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$1.80 a line, minimum 3 lines.

To figure advance payment count 5 average words as a line.

Box Numbers—Care of publication count as one line.

Discount of 10% if full payment is made in advance for 4 consecutive insertions.

Equipment Wanted or For Sale Advertisements acceptable only in Displayed Style.

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Flat & Embossed SHEETS

Die formed panels used for store fronts, signs, trailers, displays, dryers, etc. Anodized sheet supplied for all purposes.

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3235 Frankford Ave. Philadelphia 34, Pa.

REPLIES (Box No.): Address to office nearest you
NEW YORK: 330 W. 42nd St. (36)
CHICAGO: 520 N. Michigan Ave. (11)
SAN FRANCISCO: 68 Post St. (4)

BUSINESS OPPORTUNITY

Patent-Offering simple all plastic razor blade dispenser's, combined with blade conditioner. For double edge—single edge—ejector type blades. BO-1154, Product Engineering.

PROFESSIONAL SERVICES

GEORGE H. KENDALL

Consulting Mechanical Engineers

Methods Studies: Process or Product
Redesign Existing Products for Greater Profit,
Trouble Shooting Production, Design, Cost Problems,
Specialist Automatic Machinery, Process, Controls,
New Developments, Patent Studies, Investigations,
New Products & Process Engineering Studies

P. O. Box 3 (Est. 1923) Tel. Darien 5-1504
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WILLARD F. MASON

Consulting Electrical Engineers

Precision Electromechanical Designs
Specialist Slip Ring Assemblies—All Applications
Engineering Administration, Cost Systems
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Manufacturing Facilities

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MECHANICAL DESIGN ENGINEERS

Link Aviation's expanding production for industry and the military services has opened up a fruitful field for engineers with a creative yet practical approach to the solution of challenging problems in mechanical design and development.

These rewarding assignments are for men with a BS degree in Mechanical Engineering, with an advanced degree preferred. We would especially like to talk to those who have had several years' work in research and development activities. Experience with high precision measuring devices and familiarity with basic optical principles is highly desirable.

Our progressive company is located in picturesque Southern New York, an area famous for comfortable suburban living. We provide excellent employee benefits, and many opportunities for advancement in engineering and manufacturing work.

For personal interview during Design Engineering Show in Philadelphia, please call Mr. R. W. Titzel at EVergreen 6-9000 May 14-15 or write directly to:

LINK AVIATION, INC.

LINK AVIATION, INC., BINGHAMTON, N. Y.

PIONEER AND WORLD'S LARGEST PRODUCER OF JET FLIGHT SIMULATORS

A SUBSIDIARY OF GENERAL PRECISION EQUIPMENT CORP.

EMPLOYMENT OPPORTUNITIES

The Advertisements in this section include all employment opportunities—executive, management, technical, selling, office, skilled, manual, etc.

NATIONAL COVERAGE

Positions Vacant
Positions Wanted
Part Time Work

Civil Service Opportunities
Selling Opportunities Wanted
Selling Opportunities Offered

Employment Agencies
Employment Services
Labor Bureaus

DISPLAYED ——**RATES**—— **UNDISPLAYED**

The advertising rate is $23.20 per inch for all advertising appearing on other than a contract basis. Contract rates quoted on request.

An advertising inch is measured ⅞" vertically on a column—3 columns—30 inches to a page.

Subject to Agency Commission.

$1.80 per line, minimum 3 lines. To figure advance payment count 5 average words as a line.

Box Numbers—counts as 1 line.

Position Wanted ads are ½ of above rate.

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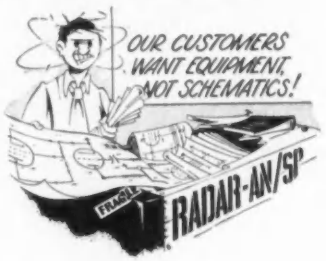
Not subject to Agency Commission.

Send NEW ADS to PRODUCT ENGINEERING, 330 W. 42nd St., N. Y. for June issue closing May 18th

MECHANICAL ENGINEERS

with experience in design of:

- Precision Mechanisms
- Radar Antenna pedestals and mounts
- Lightweight Structural members.



The recent expansion of our engineering facilities makes it possible to offer unusual opportunities to experienced creative engineers.

Beginning salary range: $6000 to $10,000.

A brief resume form and a brochure describing our new laboratory may be obtained by writing to Mr. Robert E. Doherty.

At Raytheon's new Wayland Laboratory Mechanical and Electrical engineers work together as a team to create the custom designed equipment which has enhanced Raytheon's reputation for *"Excellence in Electronics"*.

RAYTHEON MANUFACTURING COMPANY
WAYLAND LABORATORY **WAYLAND, MASS.**

RAYTHEON

- Full tuition paid for accepted educational programs.
- Location convenient for country or city living.
- Progressive salary review system.
- Liberal employee benefit program.

MACHINE DESIGNER

Graduate engineer. Age to 45. Automatic process machine design with good working knowledge of transfer applications and broad experience for the design of custom products for automation. Creative and imaginative ability to meet and analyze customers' problems.

Send resume to:

G. C. REISER, Manager
Custom Engineering

TOLEDO SCALE CO.
TELEGRAPH ROAD
TOLEDO 1, OHIO

MECHANICAL ENGINEERS AND DESIGNERS

With several years' experience in heavy machine design for work on electro-hydraulic cranes, steel hatch covers, and other marine cargo handling equipment.

WE ARE NEWLY LOCATED IN CENTRAL PHILADELPHIA

Join an old, established company in a new division with wonderful opportunities for advancement. Excellent salaries and benefits. We pay interview and relocation expenses.

Replies Confidential. Write or wire —

Mr. K. E. EYLER
MACGREGOR-COMARAIN DIVISION
NATIONAL-U. S. RADIATOR CORP.
1420 WALNUT ST. **PHILADELPHIA 2, PA.**

PRODUCT STYLING SALES EXECUTIVE

One of the largest industrial design organizations in New York has an opening for a sales executive to contact nationally known manufacturers regarding product styling. He should have the following background and characteristics:

Substantial experience in marketing, advertising, and merchandising. Knowledge of materials and manufacturing techniques and ability to use this experience effectively. Creative, imaginative and inventive, yet practical. Able to verbalize ideas rapidly whether oral or written.

Ability to understand motives of others and to size up complicated human relations situations. Enjoy contact work and find persuading others rewarding. Able to work with sustained concentration and to pay proper attention to both details and the overall aspects of the job. An effective organizer and administrator able to grow into a position of top level responsibility and decision making.

Our staff knows of this ad. Replies will be held in strict confidence.

P-1422, Product Engineering
330 W. 42 St., New York 36, N. Y.

A message to the Career-Conscious Engineer:

Ready to change jobs?

Perhaps you are not receiving a salary commensurate with your work.

Perhaps you are dissatisfied with your rate of promotion.

Perhaps you do not have enough scope for your ability in your present job.

Or perhaps you simply want to move to Southern California.

We invite you to consider the California Division of Lockheed Aircraft Corporation as the place to re-establish your career. For these reasons:

Promotional Opportunities are excellent because there are so many supervisory positions to be filled with 46 major projects in progress at Lockheed and because Lockheed is in an expanding development and production program.

You have more scope to show what you can do because Lockheed projects range across virtually the entire spectrum of aeronautical endeavor. You are not limited to one type of work because Lockheed is so diversified in projects. Moreover, Lockheed encourages and welcomes personal initiative.

You may receive a substantial increase in pay because Lockheed is extremely liberal in direct salary and in extra employee benefits, which actually increase the value of your position by an average of 14%.

Positions are open at all levels for engineers in fields of: Aerodynamics – Design – Electronics, with emphasis on systems and antenna design – Flight Test Engineering, particularly in instrumentation – Math. Analysis – Operations Research – Structures – Thermodynamics.

Space prevents us from listing all the reasons we believe you will find significant. There are many others. But if our brief remarks make sense to you, write us and we can explore your opportunities at Lockheed through personal interview or phone. The brief resumé form below is simply for your convenience in contacting us.

TO ENGINEERS WHO LACK AIRCRAFT EXPERIENCE:

Aircraft experience is not necessary to join Lockheed. It's your engineering training and experience that count. Lockheed trains you for aircraft engineering – at full pay.

Lockheed AIRCRAFT CORPORATION

California Division BURBANK **California**

E. W. Des Lauriers, Dept. CJ-30-5
Lockheed Aircraft Corporation
Burbank, California

Name

Field of Engineering

Home address

Home phone

Where employed

College

Fort Wayne, Ind.
"America's Happiest City"

Dear Bill:

Now that Joe is on the team here at Farnsworth, he's asked me to write and give you the same story that got him interested in coming with us.

Actually, Bill, it wasn't a "story." Just a few honest-to-goodness reasons why he and Marge should make the move and let the family really live as well as let Joe grow professionally.

For instance, do you know what "sold" Marge? The fact that in living here you are only 10 minutes from everywhere—schools, churches, stores etc. and Joe goes home for lunch every day instead of week-ends. She also liked the idea of some 300 lakes within 70 miles. (Guess where they're planning to spend the summer!)

As for Joe, he's all hepped up about the work he's doing on such missiles as Bomarc, Talos, Terrier and others. Says the top-notch scientists and engineers he's working with are all big-league and he's on the team.

That's about it, Bill. An engineer with your talents shouldn't be waiting around when he can get in on the ground floor here at Farnsworth in research, development or production engineering in missile guidance and control, radar, microwaves, test equipment, countermeasures, transistor applications etc.

So—why not write, right now to Don Dionne, Farnsworth Electronics Co. Fort Wayne, Ind. (a division of International Telephone and Telegraph Corp.)

You, Joe, I and Farnsworth will be mighty glad you did.

Sincerely, Jack

MECHANICAL ENGINEERS

Immediate openings in fast-growing field of

SEMICONDUCTORS

Permanent career positions with General Electric in Syracuse, New York . . . for development and design of automatic machinery for the manufacture of transistors and rectifiers.

Unusual opportunity for mechanical engineers with B.S. or M.S. degrees and experience in machine design.

Chance to work with the industry's leading engineers . . . under ideal working conditions in modern laboratories, fully equipped with all facilities.

To learn more about your G-E opportunity to live and work in the heart of New York's vacation land, write today to:

Mr. M. D. Chilcote,
Department 1-56-PE

Electronics Park
Syracuse, New York

GENERAL ELECTRIC

DIRECTOR OF ENGINEERING

We are seeking a Director of Engineering. The blueprint of his specifications includes: *"Education as an engineer. Age 35-45. At least 10 years of progress through the engineering departments of a medium-sized, or larger, packaged-processed-product (chemical or food rather than "hard" goods) manufacturer employing the most modern production techniques. Present or very recent position — chief engineer or his principal assistant with a salary of at least $12,000 a year with a company in the food, drug or allied product field. For at least the past 5 years, responsibility for all new construction and equipment as well as other engineering functions. A record of real accomplishment, rather than a potential for accomplishment."*

The salary potential is a minimum of $20,000; headquarters, Mid-Atlantic seaboard; environment, city, with a minimum of travel; potential employer, company with most modern plant in its industry.

If you are interested and can meet the qualifications stated, reply stating your present position, your education, your experience in brief resume form, full personal statistics and a brief description of that achievement you most esteem that contributed to your progress. Your reply will be kept most confidential, and any interview resulting is to be kept in strict confidence by you as well.

P-1470, Product Engineering
330 W. 42 St., New York 36, N. Y.

Mechanical Engineer
OR
Mechanical Designer

Position open for Mechanical Engineer with 3 years minimum experience or for Mechanical Designer with 7 years minimum experience. Opportunities in layout and detail design for applied research and instrumentation.

Salary commensurate with training and experience. Excellent working conditions. Liberal vacation police along with other fringe benefits. Unusual opportunity to carry on University graduate studies while working full time.

U. S. Citizenship required.

Write, giving details of education and experience to:

Technical Personnel Representative
University of Michigan
Willow Run Laboratories
YPSILANTI, MICHIGAN

ADVERTISING MAN WANTED FOR TECHNICAL PRODUCTS

Previous advertising experience not necessary but helpful. Must have at least two or three years of college with courses in engineering and technical subjects and like to write. If you have the qualifications we have an opportunity open for you. Man selected will be trained in all phases of industrial advertising. In your letter of application state age, education, positions held, and give statement of why you want a career in advertising. Location: well-known Connecticut company.

P-1211, Product Engineering
330 W. 42 St., New York 36, N. Y.

ENGINEERS,
Electronic & Mechanical
PHYSICISTS:

Top Grade Openings
At Melpar *Leader in*
Electronics Research & Development

Due to our continuing expansion program, a number of top grade openings exist in our new laboratories suburban to Washington, D. C. We urge you to consider the following:

1. At Melpar the engineer is not tied to a pre-arranged schedule of advancement. Instead, promotion and advancement are based on *individual recognition*, where skill and ability are the paramount factors of determination.

2. Melpar has doubled in size every 18 months for the past 10 years. New openings occur constantly. This enables the engineer to advance to positions of increased responsibility *as soon as he is ready.*

3. Our unique "project team" basis of organization gives the engineer an opportunity to participate in *entire* problems from conception to completion of prototype, and thus experience the "overall" approach to engineering problems necessary to eventual directorship responsibility.

4. Our new air-conditioned laboratories encompass over 285,000 square feet and offer *complete* facilities for creative research and design. In addition to our central Model Shop, supplementary facilities, personnel and test equipment are available for *immediate* use within each project group.

5. The Northern Virginia Area, suburban to Washington, D. C., in which Melpar is located, offers excellent living conditions, enjoys the Nation's highest per capita income, fine homes and schools. Recreational, cultural and educational facilities abound. Fully-accredited graduate courses are offered at the Melpar laboratories and at 5 universities in the Area.

Top Grade Openings Exist in These Fields:

Network Theory • Systems Evaluation • Microwave Technique • UHF, VHF, or SHF Receivers • Analog Computers • Magnetic Tape Handling • Digital Computers • Radar and Countermeasures • Packaging Electronic Equipment • Pulse Circuitry • Microwave Filters • Flight Simulators • Servomechanisms • Subminiaturization • Electro-Mechanical Design • Small Mechanisms • Quality Control and Test Engineering

Write for complete information. Qualified engineers and physicists will be invited to visit Melpar at Company expense.

Write: Technical Personnel Representative

MELPAR *Incorporated*
A Subsidiary of Westinghouse Air Brake Company
3061 Arlington Boulevard, Falls Church, Virginia

Positions also available at our laboratories in: Cambridge, Mass., 99 First St., Watertown, Mass., 11 Galen St.

Fort Wayne, Ind.
"America's Happiest City"

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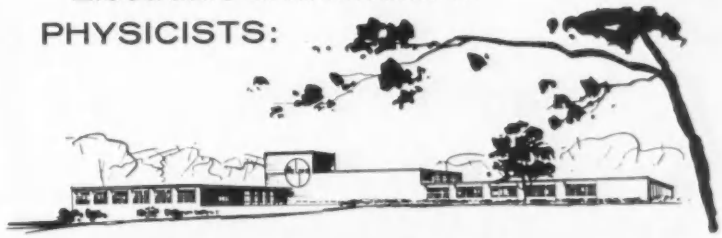
P-1211, Product Engineering
330 W. 42 St., New York 36, N. Y.

ENGINEERS,
Electronic & Mechanical
PHYSICISTS:



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3061 Arlington Boulevard, Falls Church, Virginia

Positions also available at our laboratories in: Cambridge, Mass., 99 First St., Watertown, Mass., 11 Galen St.

Machine Designers Draftsmen

• Promotions within our company have created a number of opportunities for qualified men to grow with our growing engineering organization.

If you'd like a career with a real future, with a long established company that's widely known as a good place to work, write or visit us now!

Write:* C. T. Blake, *Mgr.
Engineering Department

WARNER & SWASEY CO.
5701 Carnegie Avenue • Cleveland 3, Ohio

CONVEYOR DESIGNERS

Conveyor Designers capable of squad supervision. Opportunity with leading conveyor manufacturer. Must be willing to re-locate. Write complete details of experience and Salary expected. This information will be kept strictly confidential.

THE ALVEY-FERGUSON COMPANY
DEPARTMENT EB
CINCINNATI 9, OHIO

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Excellent opportunity for creative thinking. Scope to carry thru to completed equipment on automatic mechanical and hydraulic plant machines. Located in the ¾ million population Denver region, yet only 1 hour to Colorado rockies' hunting, fishing and skiing areas.

COORS PORCELAIN CO.
Golden, Colorado

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Prominent manufacturer located Midwest has excellent opportunity for man with at least 3 years experience in internal combustion engine application engineering as related to fluid flow design of cooling water, lubricating and fuel oil, and air piping in power plants. Must have ability to calculate size of auxiliary pumps, coolers and so forth. Some knowledge of machine design and engineering mathematics essential. Must be able to handle all application engineering required by engine contracts. Write stating age, experience, and salary expected. Replies strictly confidential.

P-1357, Product Engineering
520 N. Michigan Ave., Chicago 11, Ill.

WANTED
ENGINEERING DRAFTSMEN

Mechanical and electrical by large stable corporation. Good Future for desirable applicants. Give references, education, experience and salary expected in first letter. Location South—city of 30,000. Excellent living conditions.

P-1391, Product Engineering
520 N. Michigan Ave., Chicago 11, Ill.

ASSISTANT CHIEF ENGINEER

Moderate size manufacturer electromechanical products can offer early advancement and increased earnings for outstanding performance. Products distributed nationally through distributors and dealers. Starting salary $12,000-$14,000. Company pays agency fee and relocation expense.

MONARCH PERSONNEL 28 E. Jackson Blvd. Chicago 4, Ill.

WANTED
Electrical engineer to head up electrical division in design engineering department for plant layout work including automatic control for mechanization project. Experience in board plant or pulp mill helpful. Give education, experience and salary desired in first letter. Location south—city of 30,000. Excellent living conditions.

P-1484 Product Engineering
330 W. 42 St., New York 36, N. Y.

CHIEF PRODUCT ENGINEERS
$10,000-$15,000

(2) Turbine compressor or gas engine experience.
(1) Heavy and light portable tools.
(1) Heavy construction equipment.

Send complete resume to:
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64 E. Jackson Blvd. Suite 940
Chicago, Ill. Wabash 2-1918
PROMPT AND CONFIDENTIAL SERVICE.

NO FEE
Worldwide Placement
Design Engineers
ANN PALMER HAYNES
Industrial Personnel Consultant
1346 Conn. Ave. NW. Wash. 6, D. C.

REPLIES (Box No.): Address to office nearest you
NEW YORK: 330 W. 42nd St. (36)
CHICAGO: 520 N. Michigan Ave. (11)
SAN FRANCISCO: 68 Post St. (4)

POSITIONS VACANT

Mechanical Engineer with 5-10 years design experience in small mass-produced electrical devices wanted as Assistant to Chief Engineer in medium size plant in pleasant upstate New York community. Send complete resume to P-1136, Product Engineering.

Wanted Design Engineers—Mechanical experience automatic machinery desirable also plant layout board or pulp plants. Salary open. Reply in first letter giving details, training, experience, references and present salary range. Location South. P-1215, Product Engineering.

POSITIONS WANTED

Electrical design engineer with design and development experience and several years' experience as a practicing patent attorney wishes to obtain lucrative employment adjacent to or around New York City. Write PW-9504, Product Engineering.

Mechanical Engineer (28) B.S.M.E., M.A. in Mathematics 6 years experience in tooling and production, automatic and heavy machine design, pneumatic systems, heat transfer, pressure vessels, radar detection theory, digital computer programming. Seeks challenging position in research, development or basic design. Free to re-locate and/or travel. PW-1283, Product Engineering.

Graduate Mechanical Engineer—In the Executive capacity as factory manager, chief engineer or assistant. 19 years of diversified engineering and management in machine tools, automatic machinery and products. 7 years of practical factory operations including cost and sales. PW-1390, Product Engineering.

For RATES or INFORMATION

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HUbbard 2-7160
H. J. SWEGER

CHICAGO, 11
520 N. Michigan Ave.
MOhawk 4-5800
W. HIGGINS

CINCINNATI, 37
1915 Rockingham Ave.
REdwood 1-4537
W. H. GARDNER

CLEVELAND, 15
1510 Hanna Bldg.
SUperior 1-7000
W. SULLIVAN

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Adolphus Tower
Main & Akard Sts.
G. L. JONES

DETROIT, 26
856 Penobscot Bldg.
WOodward 2-1793
L. SEEGAR

LOS ANGELES, 17
1125 W. 6th St.
MAdison 6-9351
H. L. KEELER

NEW YORK, 36
330 West 42 St.
LOngacre 4-3000
R. LAWLESS
D. COSTER
S. HENRY

PHILADELPHIA, 3
17th & Sansom St.
RIttenhouse 6-0670
E. MINGLE
H. BOZARTH

ST. LOUIS, 8
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JEfferson 5-4867
W. HIGGENS

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R. L. ALCORN

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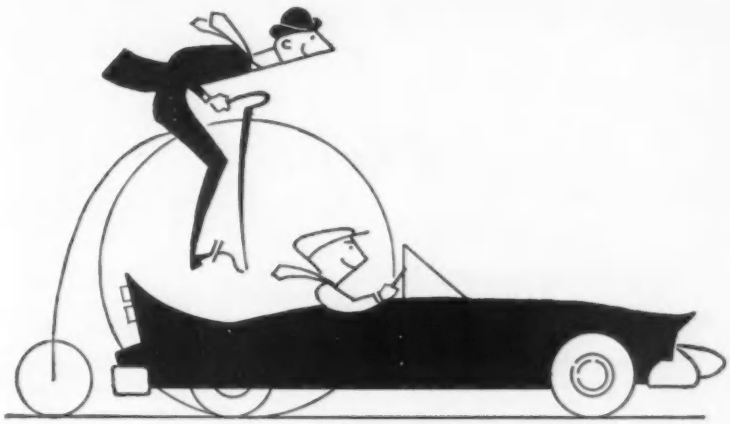


DESIGN OPPORTUNITIES AHEAD WITH WHITNEY CHAIN DRIVES

When designing or replacing power transmission or conveyor drive units, the adaptability of Whitney Chain Drives provides economical design and increased production. Whitney Chain Drives assure utmost efficiency . . . provide positive, reliable performance in all types of service from fractional to hundreds of horsepower.

Important . . . when considering your chain source. Whitney Chain has specialized in finished steel precision chain drives since 1896 when Whitney pioneered the famous alloy steel bicycle chain. Whitney's undivided concentration on producing quality precision chain drives is backed by complete factory warehouse stocks and engineering service across the country.

Write for descriptive literature — or call your nearest Whitney Field Office for prompt and practical engineering assistance on all drive problems.

Whitney

CHAIN COMPANY

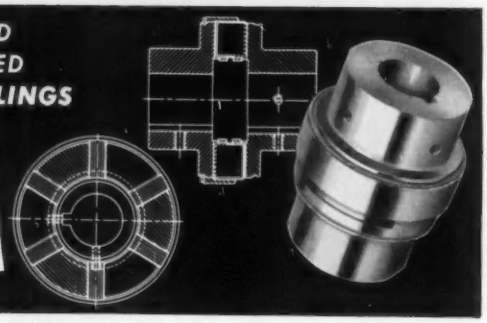
204 HAMILTON STREET, HARTFORD 2, CONNECTICUT

ROLLER CHAIN • SILENT CHAIN • CONVEYOR CHAIN • SPROCKETS • FLEXIBLE COUPLINGS

LOVEJOY Power Transmission Equipment

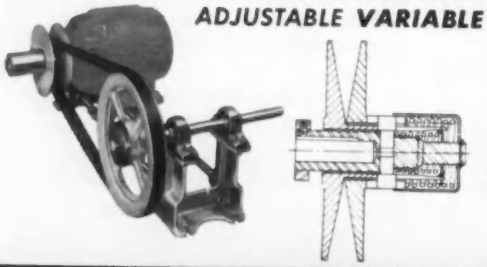
Job-Rated for the Particular Load to Give Maximum Performance on Your Job

NON-LUBRICATED EASILY-ASSEMBLED FLEXIBLE COUPLINGS



Bores (max.) .....⅜" to 9½"
O.D. .....⅝" to 21⅛"
Wt. .....½ oz. to 1500 lb.
H.P. .....1/20 to 3000
Torque (static)..1½ to 5100 ft.-lbs.

MAINTENANCE-FREE INSTANTLY-ADJUSTABLE VARIABLE SPEED PULLEYS

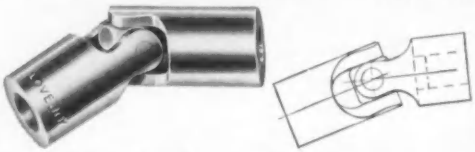


Bores (max.) .....½" to 1⅜"
O.D. .....3" to 13⅜"
Belt Sizes.....A to 2⅜ TW
Speed Ratios.....1-1 to 8-1
H.P. (1750 rpm.)....¼ to 15

ECONOMICALLY-PRICED INFINITELY-VARIABLE SELECT-O-SPEED TRANSMISSIONS

Controls - Lever or Hand Wheel
Belt Sizes.....A to C
Speed Ratios.....1-1 to 10-1
H.P. (1750 rpm.)...½ to 7½

LIGHT-WEIGHT PRECISION-BUILT UNIVERSAL JOINTS



Bores.....¼" to 2"
Hub Dia. .....½" to 4"
Static Torque 340 to 130700 in.-lbs.
H.P. (100 rpm.).....½ to 207

Get Lovejoy performance for your equipment. Request full information now.

LOVEJOY FLEXIBLE COUPLING CO.

4873 WEST LAKE STREET • CHICAGO 44, ILLINOIS

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IN ADDITION TO ITS REGULAR LINE of precision gears, one of New England's oldest and ablest gear-engineering organizations is now fully equipped to produce fine pitch gears to your own specifications. Any size and quantity... any type of basic material, metallic or non-metallic. Complete heat-treating facilities.

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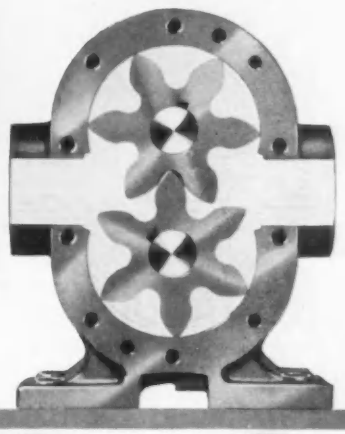
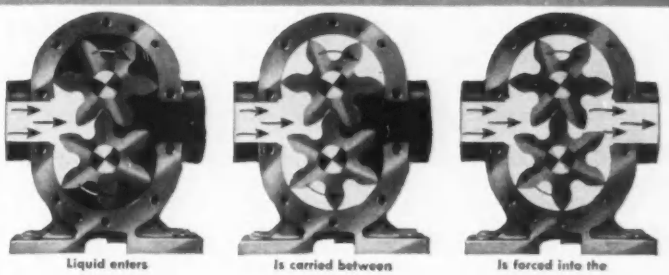
only 2 moving parts HELP MAKE ROPERS DEPENDABLE





Liquid enters the pump

Is carried between the teeth

Is forced into the discharge line

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HOW IT OPERATES — The unmeshing of the gears produces a vacuum, drawing the liquid into the tooth spaces. The liquid is carried between the teeth and case to the opposite side of the pump. The meshing of the gears forces the liquid into the discharge line. This is a positive displacement pump. The Roper principle is simple in design. It has only two moving parts — equal size pumping gears — operating in a case with proper amount of clearance to promote high efficiency and long life.

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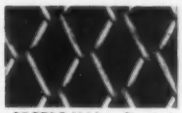
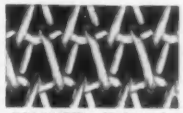
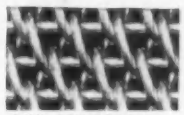


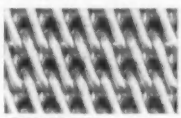
SECTIONAL — Simplest weave, for light loads where low initial cost is desired.



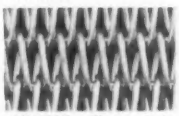
BALANCED—High tensile strength, low ultimate cost belting for operation up to 1300°F. Resists distortion, designed for straight travel.



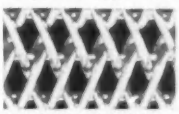
ROD-REINFORCED — Highest tensile strength and low thermal capacity. It is recommended for high temperatures, up to 2100°F. Undergoes minimum elongation and width contraction.



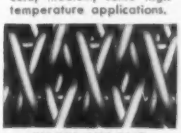
DUPLEX — Compact structure of great density provides high tensile strength. The close mesh provides smooth surface for carrying small parts and plastic materials.



GRATEX — Close spirals retain the advantages of Balanced weave, while adding strength. For cold, medium and some high temperature applications.



DOUBLE BALANCED— A widely used weave combining open mesh of Balanced weave with the strength of Gratex. For cold, medium, some high temperature applications.



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CORDUROY

INTERWOVEN

How to select WOVEN WIRE CONVEYOR BELTS for Continuous Processing

As you know, woven wire conveyor belts are widely used for combining movement with processing in many continuous operations—heat treating metal parts; washing, blanching and freezing food products; annealing and decorating glassware; washing and curing chemicals and plastics.

However, there is no single type of belt construction suitable for all processes. Some require a smooth belt surface, some exceptional strength, others high corrosion resistance. That's why Cambridge has nine basic weaves available. Each is shown here with the important characteristics of the six most frequently used. The last three are special-purpose weaves for installations requiring exceptionally smooth surface and dense mesh for very small parts.

There are several factors that generally influence selection of weave, mesh size and metal or alloy from which the belt will be woven. Among them are: size, weight and shape of product to be handled; temperatures to which belt will be subjected; presence of wet or corrosive conditions. Even after these have been decided, overall belt construction must be designed to meet individual requirements—type of drive, selvage, support and special surface attachments must be selected.

You can see, then, that designing for continuous processing with woven wire conveyor belts is not a simple "nuts and bolts" job. Ramifications build up rapidly to demand the service of a specialist. That's why Cambridge maintains a staff of competent Field Engineers to help you select the Woven Wire Conveyor Belt to make your installation most efficient. You can rely on the experience of these engineers to specify just the right belt for you. In addition, they are thoroughly familiar with basic conveyor design. For the name of your nearest Cambridge Field Engineer, look under "Belting, Mechanical" in your classified telephone book. Or, write direct. Also ask for 130-page Reference Manual of specifications and design information.

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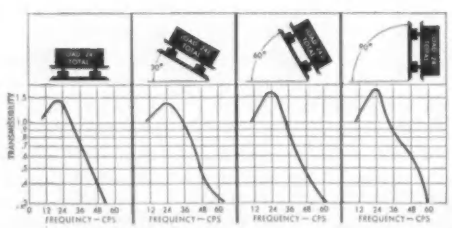

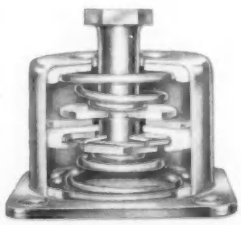

Write now for data sheets AA-0-1 containing detailed performance data. And remember — when your problem is protection thru every flight attitude, your answer is ALL-ANGL Barry Mounts. For recommendations, call your nearest Barry Sales Representative.

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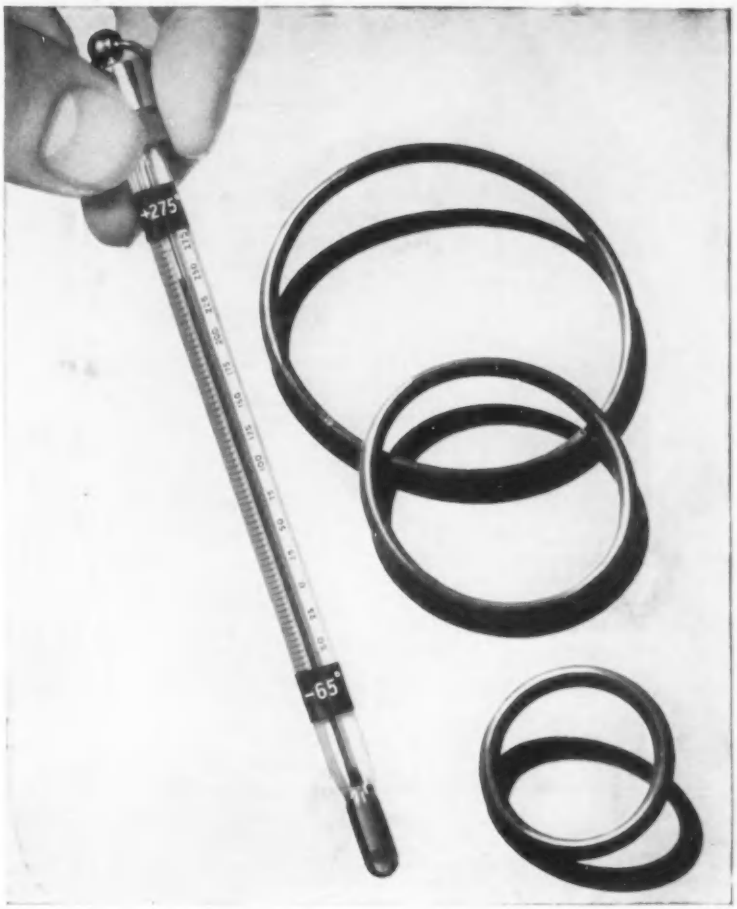

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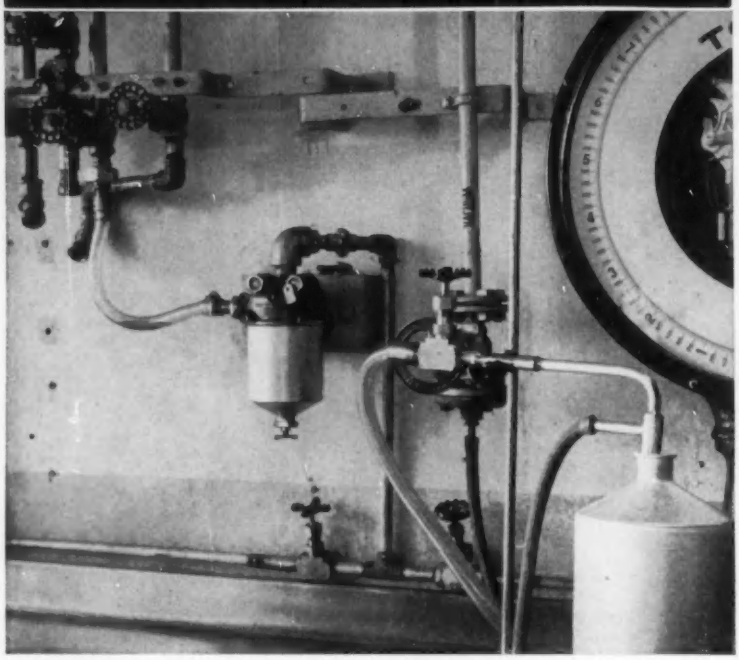

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To get more data about new Components, Materials and Parts fully described on pages 240-354, just circle the appropriate key number.

To get more information about advertised products, circle the page number of the advertisement in which you are interested. If more than one advertisement is located on a single page, letters preceding number identify each advertisement. Key: T—Top; B—Bottom; R—Right: L—Left; TL—Top left; BL—Bottom left; TR—Top right; BR—Bottom right.

For specialized data . . . prices, sizes available, nearest source of supply, etc. . . . do not circle key number but indicate your needs in the space alloted at the bottom of the card. Use this space, too, if information about a specific product among several mentioned in an advertisement is desired.

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READER SERVICE DEPARTMENT
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Company _____

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5-56

NEW PRODUCTS... Description of these new engineering materials appear on pages 240-354. Circle key number for more data

1—Single-Stage Torque Converter
2—Rectangular Electric Motors
3—Rigidized Tube-In-Strip
4—Drive Belt With V-Shaped Tread
5—Servo Motor and M-G Set
6—Recording Tape Cartridges
7—Automatic V-Belt Clutch
8—Synchronous Induction Motor
9—Plug-in Static Switching Units
10—Recording Tape Cartridge
11—Fold-Away Drafting Board
12—Battery with Solid Electrolyte
13—Adjustable Flow Regulator
14—Miniature Solenoid Valve
15—Silicon Power Rectifiers
16—Relay and Solenoid Combined
17—Anti-Vibration Fastener
18—Photosensitive Selenium Elements
19—Forward and Reverse Transmission
20—High-Speed Automatic Air Valves
21—Hand Pump Pressure Oiling System
22—Converts 60 to 360 Cps.
23—Woven Asbestos Friction Material
24—Rod End Bearings
25—Self-Locking Insert
26—Knee-Action Double-Wheel Caster
27—Rack and Panel Connector
28—Two Pressure Switches In One
29—Printed Circuit Laminates
30—Fixed Setting Thermostat
31—Axial Blower
32—A-c Rotary Solenoid
33—High Capacity Vibration Isolators
34—Contact Relays
35—Hysteresis Synchronous Motor
36—Geared Servo Motors
37—Two-Lever Switch
38—Check Valve in One-Piece Housing
39—Metering Valve
40—Steel Needle Valves
41—Air Cylinders
42—High-Capacity Motor Capacitors
43—Single-Pole Single-Circuit Switch
44—Flanged, Silent Check Valve
45—Electric Motors, 1/6 to 125 HP
46—A-c Servo Motor
47—Nylon Tube Fitting
48—Motor-Alternator Sets
49—Miniature Indicator Lamp
50—Multi-Purpose Spool Valve
51—Miniature Rectifiers
52—Potentiometer for −57C to 125C
53—Variable Speed Drives
54—Silicone Rubber Compounds
55—Battery-Operated Vibration Meter
56—Self-Aligning Tube Fitting
57—Electric Motor Starter
58—Miniature Universal Joint
59—Tachometer Takeoff Heads
60—Motor-Driven Sampling Switch
61—Momentary Contact Switches
62—Speed Reducer
63—Subminiature Transistor
64—Magnetic Amplifier Relay
65—Explosion-Proof Motor
66—High Efficiency Air Filters
67—Fhp 1550 Rpm Motor
68—Electric Tachometer
69—Molded Bumpers
70—Motor Winding Thermostat
71—Miniature Wafer Switch
72—Subminiature Switch
73—Iron Powder Spur Gears
74—Connector with Hermetic Seal

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USE THIS SPACE TO INDICATE REQUIRED.....

75—Adustable Thermostat
76—Pushbutton and Selector Switches
77—Multiple Passage Rotary Joint
78—Miniature Speed Control
79—Oil Fog Lubricator
80—Swivel Caster That Locks
81—Hermetically Sealed Switch
82—Six-Digit Counter
83—Snap-Action Torque Solenoid
84—Through-Shaft Magnetic Disk Brake
85—Motor Base for V-Belt Drives
86—Four-Way Solenoid Valve
87—Miniature Lampholders
88—Miniature Clutch-Brakes
89—Molded Plastic Handle
90—Self-Aligning Duplex Bearing
91—Snap-Back Recessed Handles
92—Self-Aligning Roller Bearings
93—Control Thyratron
94—Single-Turn Potentiometers
95—Subminiature Relay
96—Tandem Transistor
97—Differential Regulator
98—Pushbutton Switch
99—Regulated D-c Power Supplies
100—Fastener for Small Doors
101—Solenoid-Operated Air Valve
102—Double-Pipe Heat Exchangers
103—Plastic Tube Fittings
104—Rectangular Meters
105—Battery for Stationary Power
106—D-c Power Supply
107—Short-Stroke 5.5 Hp Engine
108—Panel Mounting Switch
109—Miniature Noise Filter
110—Solder Paste in Squeeze Bottle
111—Servo Motor-Generator
112—PVC Plug Valve
113—Mist Lubrication Control
114—Adjustable, All-Metal Mount
115—Thermistor Kit
116—Automatic A-c Regulator
117—Thermistor Reference Kit
118—High Voltage Tester
119—Vacuum Tube Voltmeter
120—Plastic Cover Limit Switches
121—Small Ellipses Templates

NEW BULLETINS . . . listed below are described on page 355-365. Circle key number for your copy.

122—Synchros, Servos, Resolvers
123—Roller Bearings
124—Locknuts
125—Fasteners for Spotwelding
126—Molded Friction Elements
127—Fluorocarbon Rubber
128—Solenoids
129—Heaters and Heating Devices
130—Compressed Air
131—Stainless Steel Wire
132—Air or Oil Cylinders
133—Ball Bearings
134—Electronic Terminals, Seals
135—Magnesium Alloy Nomenclature
136—Chemical Metal Finishing
137—Variable Speed Transmissions
138—Nylon Molding Powder
139—Pilot Light Assemblies

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PRODUCTS ADVERTISED

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TR469	BR469	L470	R470	471	472	473	L474	TR474	BR474	475	L476	R476	477
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NEW PRODUCTS . . .

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SPECIFIC DATA . . .

Card expires July 1

140—Indexing Machinery
141—Hydraulic Controls
142—Ball Screws and Splines
143—Titanium
144—Indexing Turntables
145—Wire-Wound Resistors
146—Hydraulic Valves
147—Noise Control
148—Collodial Dispersions
149—Rubber-to-Metal Bonds

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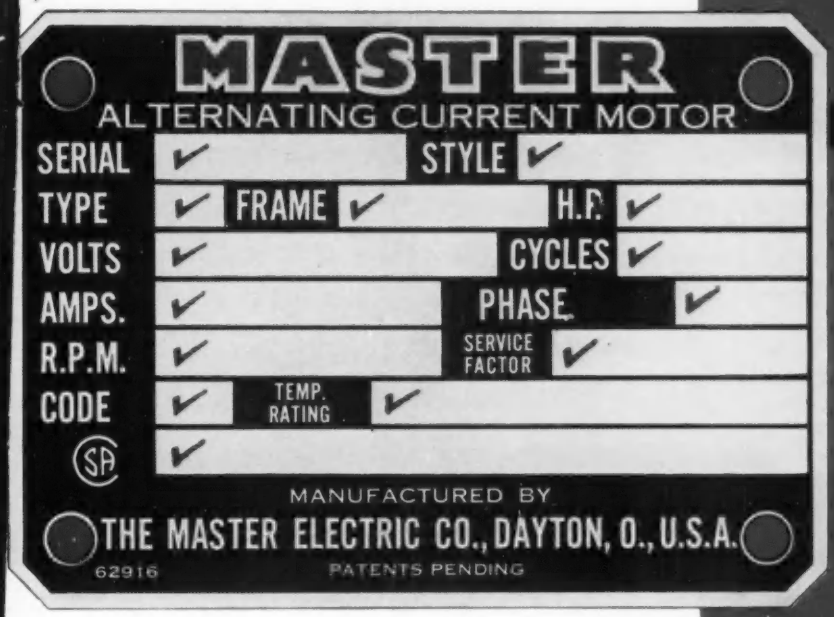


What are your power drive requirements? Here at Master, with the widest selection in the nation to choose from, you're sure to fill your needs quickest and best.

Need something special in gear reduction—electric brakes—variable speed operation—fluid drive or special mounting? Or would some of our standard models (⅛ to 400 H.P.) fill the bill? You'll find the answer here! And remember, all Master components are engineered to form combinations of units in one streamlined, compact package of efficiency. Name your need and the name that fills it is Master—for greater salability of motor driven products; for increased productivity of plant equipment.

Motor Ratings..⅛ to 400 H.P. All phases, voltages and frequencies.

Motor Types.....Squirrel cage, slip ring, synchronous, repulsion-start induction, capacitor, direct current.

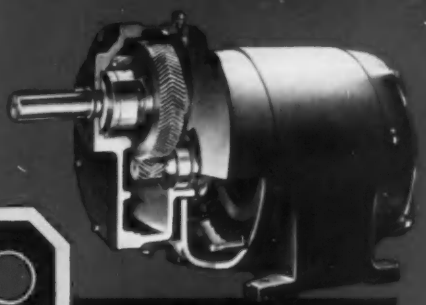
Construction ....Open, enclosed, splash-proof, fan-cooled, explosion-proof, special purpose.

Speeds .....Single speed, multi-speed, and variable speed.

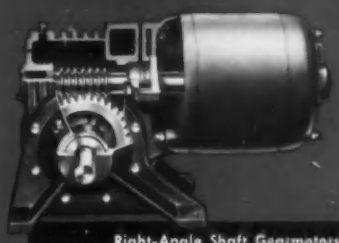
Installation .....Horizontal or vertical, with or without flanges and other features.

Power Drive Features .....Electric brakes (2 types)— 5 types of gear reduction up to 432 to 1 ratio. Mechanically and electronically-controlled variable speed units—fluid drives—every type of mounting.

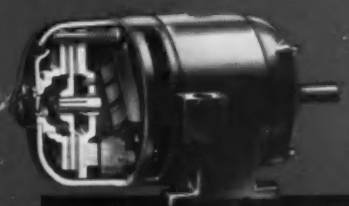
THE MASTER ELECTRIC COMPANY
DAYTON 1, OHIO



Parallel Shaft Gearmotors

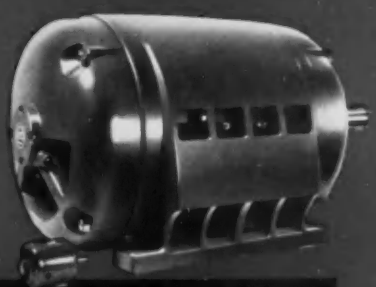


Right-Angle Shaft Gearmotors



Unibrake Motors

Speedrangers

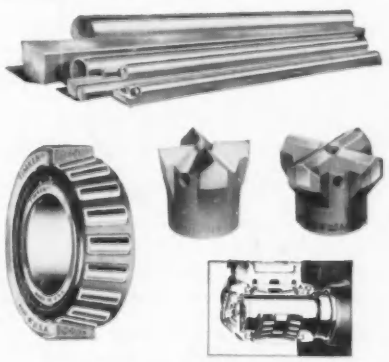


Standard Motors—⅛ to 400 H.P.

You mean what you say, when you say "TIMKEN"

IF you are content with just any old kind of tapered roller bearing, steel or rock bit, of course you don't specify "Timken". By the same token, when you want highest quality you don't specify anything *but* "Timken". To make sure you get what you want—to safeguard your reputation and ours—we stamp "Timken" on every product we make. When you say "Timken" we know you *mean* a product made by the Timken Company . . . because, as everyone is aware, "Timken" is a trade-mark, not *just a type of product.*

When you purchase tapered roller bearings, alloy steel bars, seamless steel tubing or removable rock bits, always look for this famous legal identification. When you see it, you know there are over 55 years of experience behind it. When you *say* it, you're saying exactly what you mean: "I want the best." The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ontario. Cable address: "TIMROSCO".



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